LABORATORY MANUAL

Workshop Practice - II

(ME 392)

Department of Mechanical Engineering

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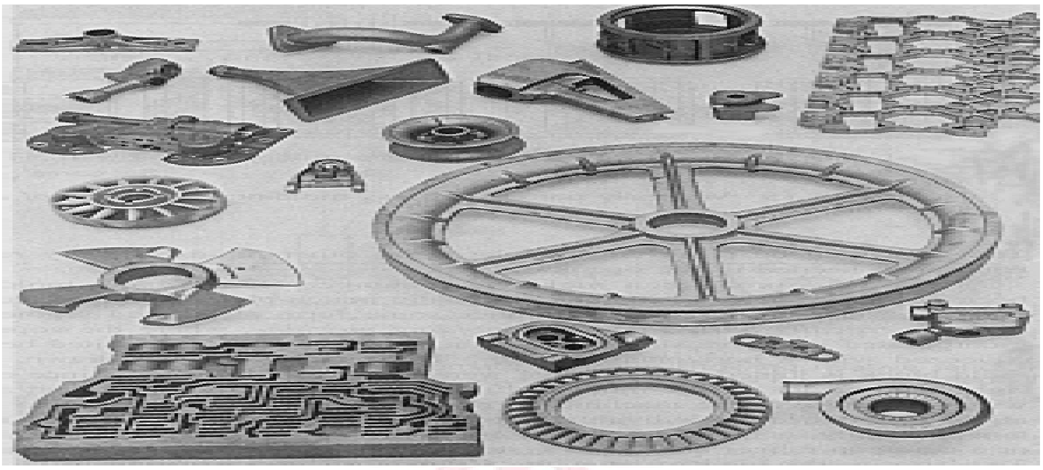
Pattern Making, Sand Moulding AND Casting



Department of Mechanical Engineering

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PATTERN MAKING, SAND MOULDING AND CASTING

OBJECTIVES:

1. To prepare a wooden pattern for given object
2. To prepare a sand mould from the prepared pattern for casting a iron block as shown
3. To melt and pour iron metal into the mould.

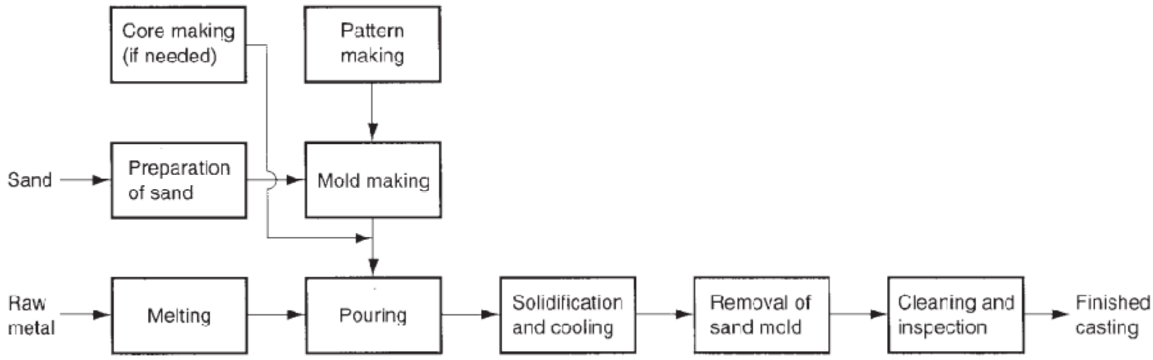

Fig. The basic production steps in sand casting

EQUIPMENT AND MATERIALS:

Pattern, molding flasks, molding tools, sand muller, riddle, sand, molasses, bentonite, melting furnace, fluxes, pouring ladle, pyrometer, hacksaw, file.

PATTERN:

The pattern is the principal tool during the casting process. It can be said as a model or the replica of the object to be cast except for the various allowances a pattern exactly resembles the casting to be made. It may be defined as a model or form around which sand is packed to give rise to a cavity known as mold cavity in which when molten metal is poured, the result is the cast object. When this mould/cavity is filled with molten metal, molten metal solidifies and produces a casting (product). So the pattern is the replica of the casting.

The pattern is always made somewhat larger than the final job to be produced. This excess in dimensions is referred to as the pattern allowances. There are mainly three categories of pattern allowances, namely, i) Shrinkage allowance, ii) Machining allowance and iii) Draft or Taper Allowance. **Shrinkage allowance** is provided to take care of the contraction of a casting. Machining operations are required to produce the finished surface of the final product of the casting. The excess in dimensions of the casting (and consequently in the dimensions of the pattern) over those of the final job to take care of the machining is called **Machining allowance. Taper allowance** is a positive allowance and is given on all the vertical surfaces of pattern so that its withdrawal becomes easier. The normal amount of taper on the external surfaces varies from 10 mm to 20 mm/mt.

The most commonly used pattern material is wood, since it is readily available and of low weight. Also, it can be easily shaped and is relatively cheap.

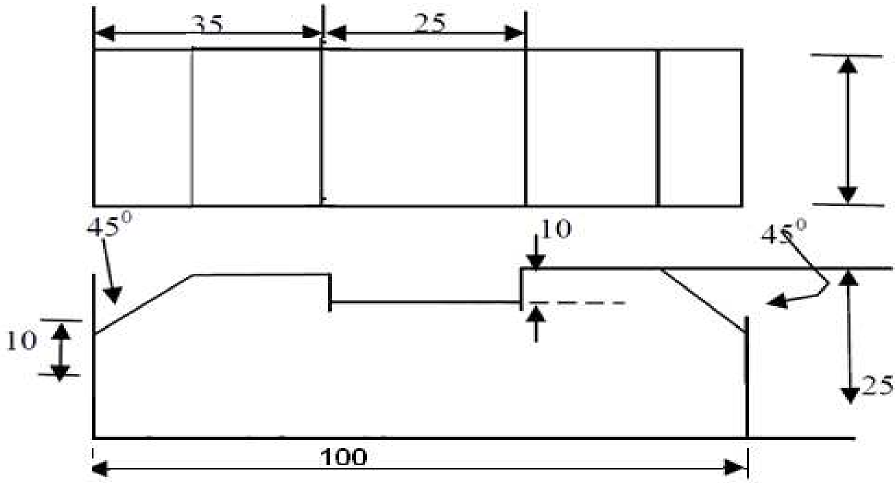

Fig.: Job_1 for making a pattern

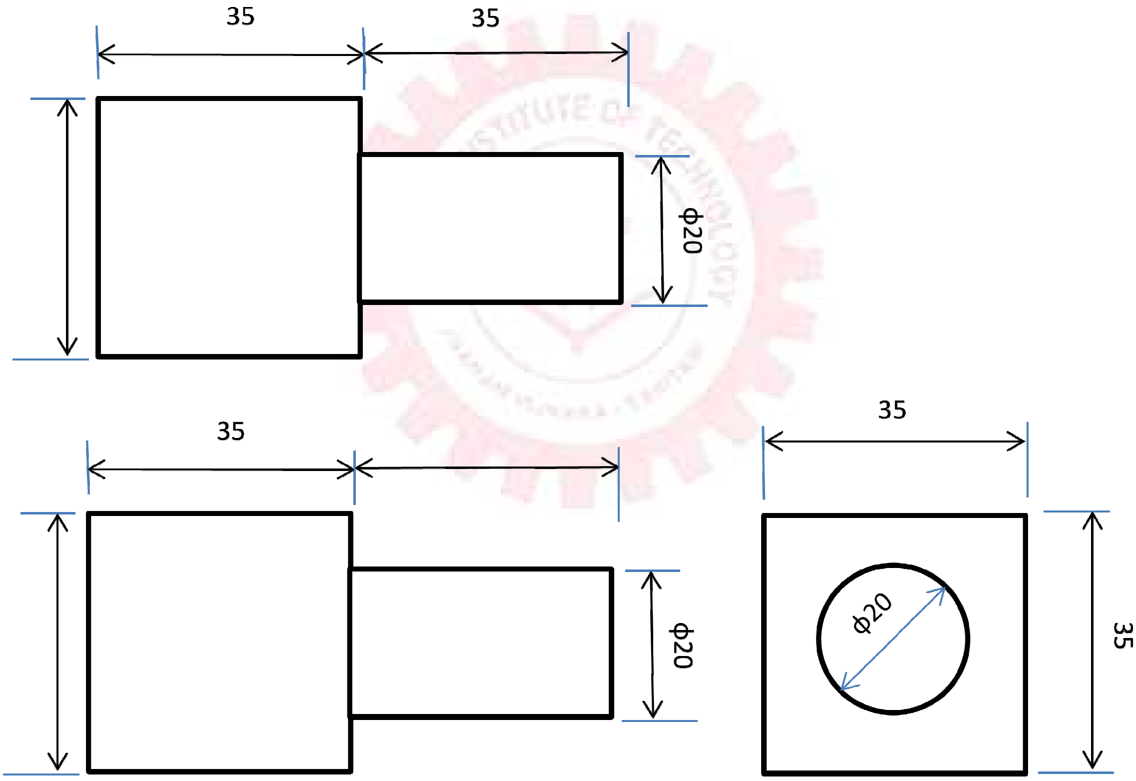

Fig.: Job_2 for making a pattern

CASTING:

Casting process is one of the earliest metal shaping techniques known to human being. It means pouring molten metal into a refractory mold cavity and allows it to solidify. The solidified object is taken out from the mold either by breaking or taking the mold apart. The solidified object is called casting and the technique followed in method is known as casting process.

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Any casting process involves three basic steps, i.e. mold making, melting and pouring of metals into the mold cavity, and removal and finishing of casting after complete solidification.

SAND CASTING PROCESS:

Sand is one of the cheaper, fairly refractory materials and hence commonly used for making mold cavities. Sand basically, contains grains of silica (SiO_2) and some impurities. For mold making purposes sand is mixed with a binder material such as clay, molasses, oil, resin etc. The typical foundry sand is a mixture of fresh and recycled sand, which contains approximately 70-85% silica (SiO_2), 3-6% water, 10-20% clay, and 1-6% additives.

The grain size and grain shape are very important as they define the surface quality of casting and the major mold parameters such as strength and permeability:

i) Bigger grain size results in a worse surface finish
ii) Irregular grain shapes produce stronger mold
iii) Larger grain size ensures better permeability

OTHER CASTING PROCESSES:

INVESTMENT CASTING (LOST WAX CASTING):
In investment casting, the pattern is made of wax, which melts after making the mold to produce the mold cavity.

PERMANENT MOLD CASTING PROCESSES:
In contrary to sand casting, in permanent mold casting the mold is used to produce not a single but many castings.

HOT-CHAMBER DIE-CASTING:
In hot chamber die-casting, the metal is melted in a container attached to the machine, and a piston is used to inject the liquid metal under high pressure into the die.

COLD CHAMBER DIE CASTING:
In cold-chamber die-casting, molten metal is poured into the chamber from an external melting container, and a piston is used to inject the metal under high pressure into the die cavity.

CENTRIFUGAL CASTING:
In centrifugal casting, molten metal is poured into a rotating mold to produce tubular parts such as pipes, tubes, and rings.

PROCEDURES:

MOLD MAKING:

i. Place the drag part of the pattern with parting surface down on ground or molding board at the center of the drag (flask).
ii. Riddle molding sand to a depth of about 2 cm in the drag and pack this sand carefully around the pattern with fingers.
iii. Heap more molding sand in the drag and ram with rammer carefully.

iv. Strike off the excess sand using strike bar.
v. Make vent holes to within 1 cm of the pattern surface in the drag.
vi. Turn this complete drag and place the cope portion (flask) over it.
vii. Place the cope half of the pattern over the drag pattern matching the guide pins and apply parting sand over the parting surface. Also place the sprue pin and riser pin in proper positions.
viii. Complete the cope half by repeating steps (ii) to (v).
ix. Remove the sprue and riser pins and make a pouring basin. Separate the cope and drag halves, and place them with their parting faces up.
x. Moisten sand at the copes of the pattern and remove pattern halves carefully using draw spikes.
xi. Cut gate and runner in the drag. Repair and clean the cavities in the two mold halves.
xii. Assembled the two mold halves assemble and clamp them together.

MELTING AND POURING:

i. Melt the metal in the furnace. Use appropriate fluxes at proper stages and measure metal temperature from time to time.
ii. Pour the molten metal into the pouring ladle at a higher temperature (say 100oC higher) than the pouring temperature. As soon as the desired pouring temperature is reached, pour the liquid metal into the mold in a steady stream with ladle close to the pouring basin of the mold. Do not allow any dross or slag to go in.
iii. Allow sufficient time for the metal to solidify in the mold. Break the mold carefully and remove the casting.
iv. Cut-off the riser and gating system from the casting and clean it for any sand etc.
v. Inspect the casting visually and record any surface and dimensional defects observed.

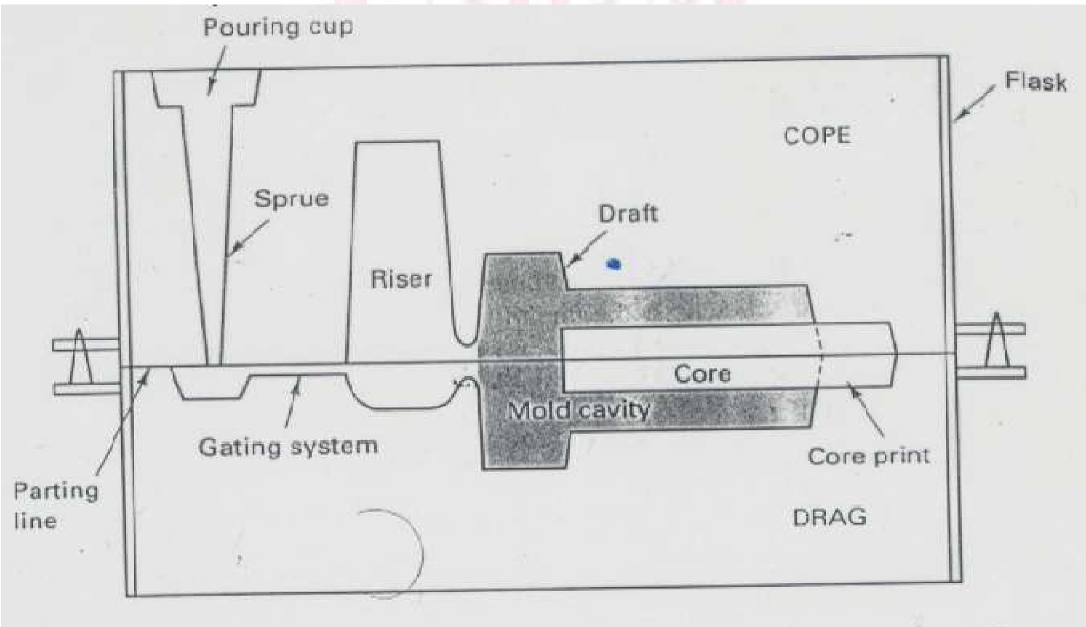


Fig. shows the various parts of a typical sand mold.

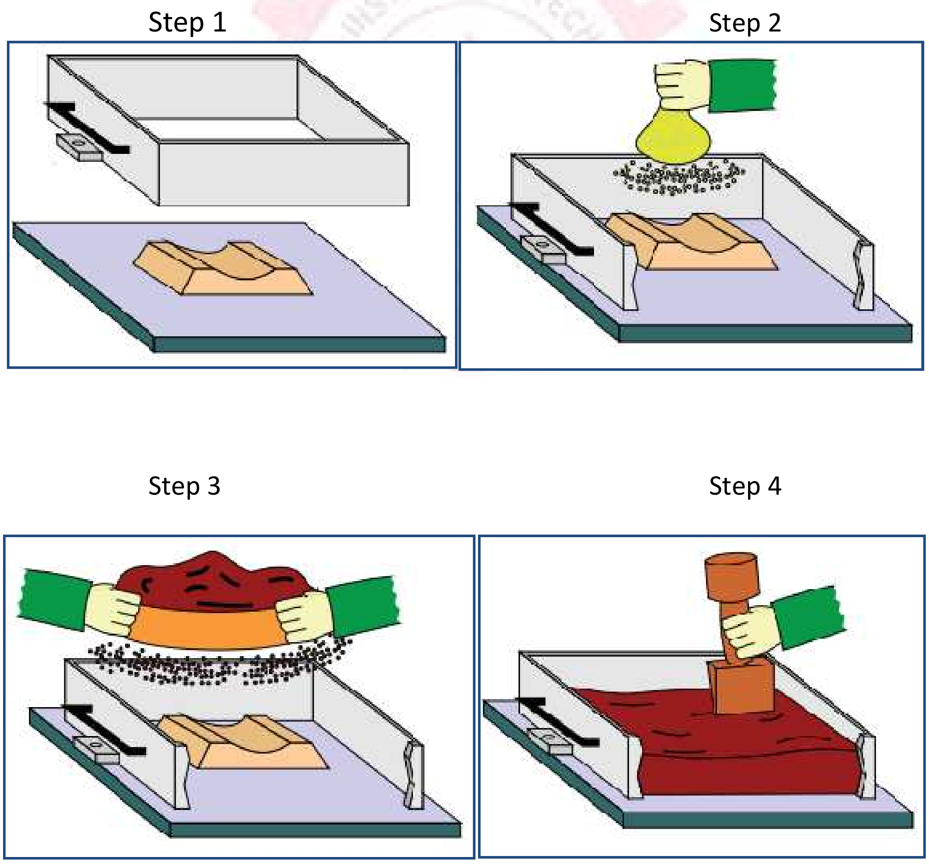
MELTING AND POURING OF METALS:

The next important step in the making of casting is the melting of metal. A melting process must be capable of providing molten metal not only at the proper temperature but also in the desired quantity, with an acceptable quality, and within a reasonable cost. In order to transfer the metal from the furnace into the molds, some type of pouring device, or ladle, must be used. The primary considerations are to maintain the metal at the proper temperature for pouring and to ensure that only quality metal will get into the molds.

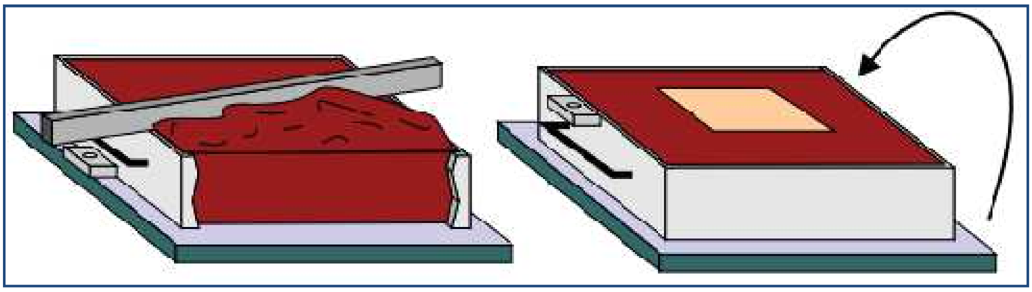
REMOVAL AND FINISHING OF CASTINGS:

After complete solidification, the castings are removed from the mold. Most castings require some cleaning and finishing operations, such as removal of cores, removal of gates and risers, removal of fins and flash, cleaning of surfaces, etc.

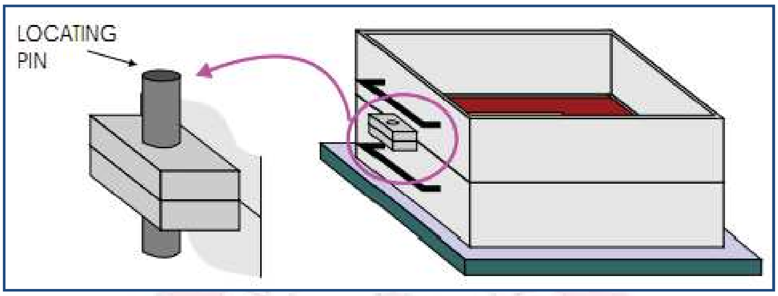
SCHEMATIC ILLUSTRATION OF THE SEQUENCE OF OPERATIONS FOR SAND CASTING:



Step 5



Step 6



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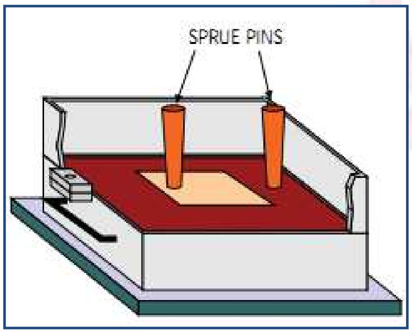
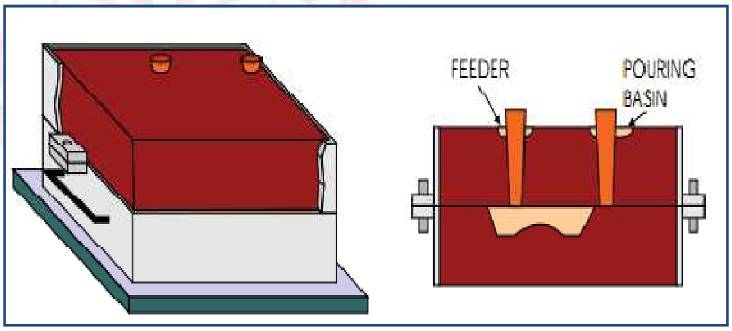
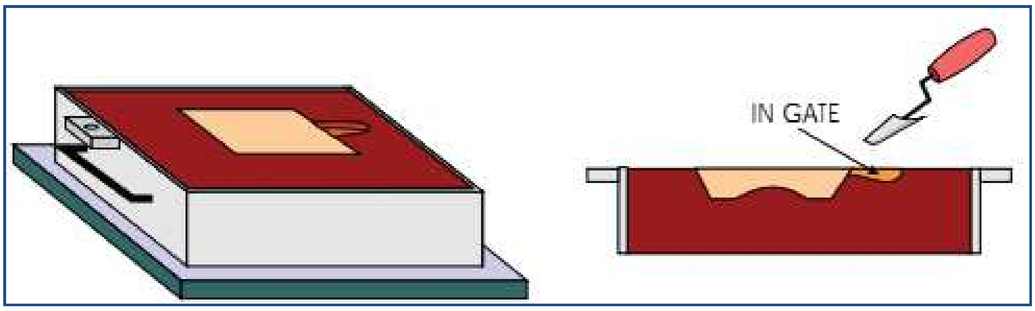


Step 8



Step9



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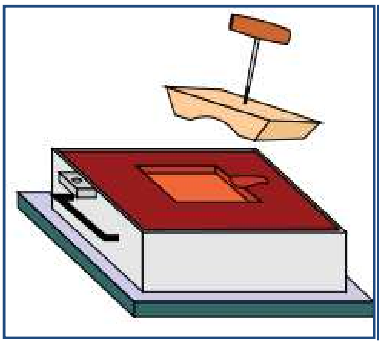
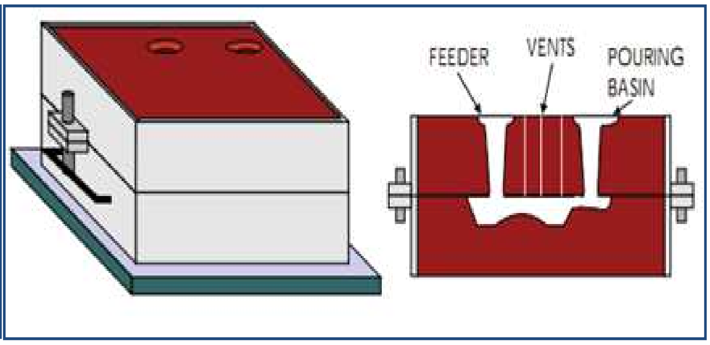
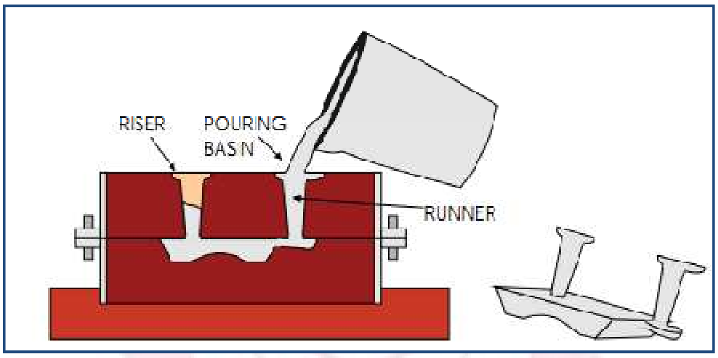
Step 10 Step 11



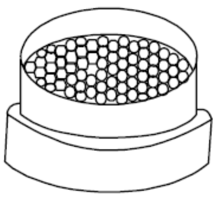


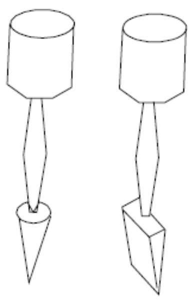
Step 12

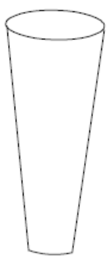


MOLDING TOOLS:

Several hand tools, such as rammer, trowel, hand riddle, shovel, rammers, Strike off bar, Mallet, Draw spike, Vent rod, Lifters, Trowels, Slicks, Smoothers, Spirit level, Gate cutter, Bellows etc. are used as aids in making a mold.







Hand riddle Shovel Rammers Sprue pin

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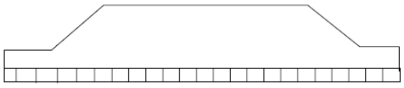
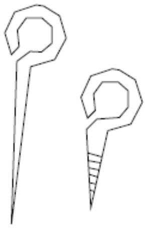


Strike off bar



Draw spike

Vent rod

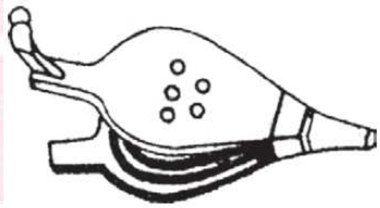
Lifter

Trowel

Slick

Smoother

Gate cutter



Bellows

CASTING QUALITY:

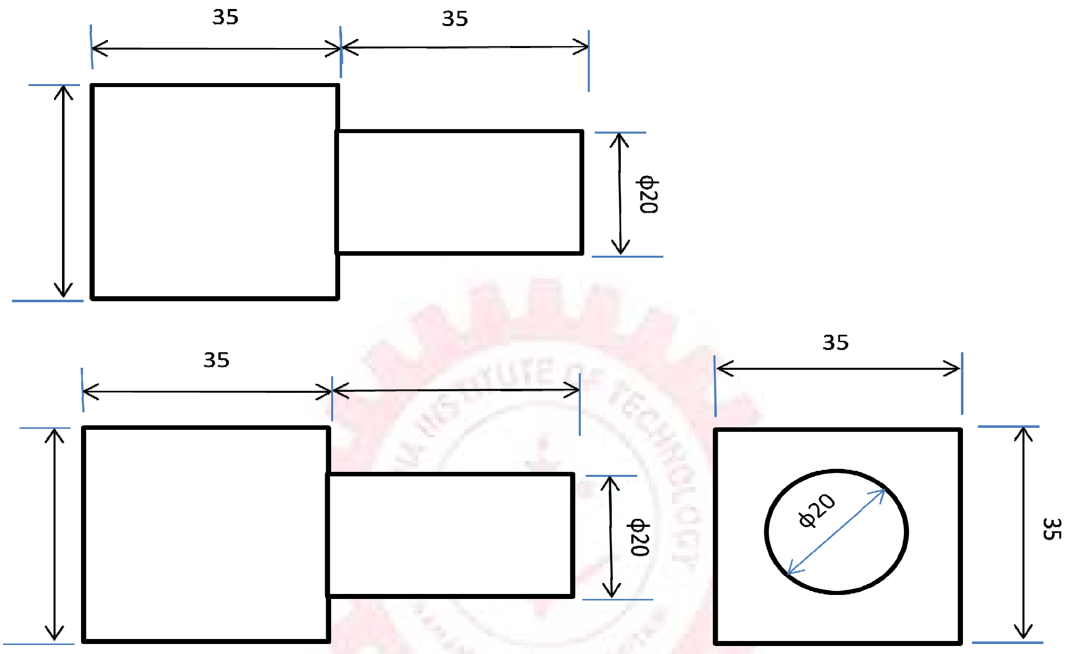
There are numerous conditions in the casting operation for different defects to appear in the cast product. Some of them are common to all casting processes:

1. Misruns: Casting solidifies before completely fill the mold. Reasons are low pouring temperature, slow pouring or thin cross section of casting.
2. Cold shut: Two portions flow together but without fusion between them. Causes are similar to those of a misrun.
3. Cold shots: When splattering occurs during pouring, solid globules of metal are entrapped in the casting. Proper gating system designs could avoid this defect.
4. Shrinkage cavity: Voids resulting from shrinkage. The problem can often be solved by proper riser design but may require some changes in the part design as well.
5. Micro-porosity: Network of small voids distributed throughout the casting. The defect occurs more often in alloys, because of the manner they solidify.
6. Hot tearing: Cracks caused by low mold collapsibility. They occur when the material is restrained from contraction during solidification. A proper mold design can solve the problem.

LABORATORY EXERCISE_1

PATTERN MAKING

AIM: To prepare a wooden pattern for given object of given dimensions.



TOOLS REQUIRED:

SEQUENCE OF OPERATIONS:

RESULT:

PRECAUTIONS:

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LABORATORY EXERCISE_2

MOULD MAKING

AIM: To prepare a sand mold from the prepared pattern.

TOOLS REQUIRED:

SEQUENCE OF OPERATIONS:

RESULT:

PRECAUTIONS:

LABORATORY EXERCISE_3

CASTING

AIM: To melt and pour wax into the mould.

TOOLS REQUIRED:

SEQUENCE OF OPERATIONS:

RESULT:

PRECAUTIONS:

FITTING SHOP

DEPARTMENT OF MECHANICAL ENGINEERING

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FITTING

INTRODUCTION:

Machine tools are capable of producing work at a faster rate, but, there are occasions when components are processed at the bench. Sometimes, it becomes necessary to replace or repair component which must be fit accurately with another component on reassembly. This involves a certain amount of hand fitting. The assembly of machine tools, jigs, gauges, etc, involves certain amount of bench work. The accuracy of work done depends upon the experience and skill of the fitter.

The term 'bench work' refers to the production of components by hand on the bench, where as fitting deals which the assembly of mating parts, through removal of metal, to obtain the required fit.

Both the bench work and fitting requires the use of number of simple hand tools and considerable manual efforts. The operations in the above works consist of filing, chipping, scraping, sawing drilling, and tapping.

HOLDING TOOLS:

BENCH VICE:

The bench vice is a work holding device. It is the most commonly used vice in a fitting shop. The bench vice is shown in Figure.

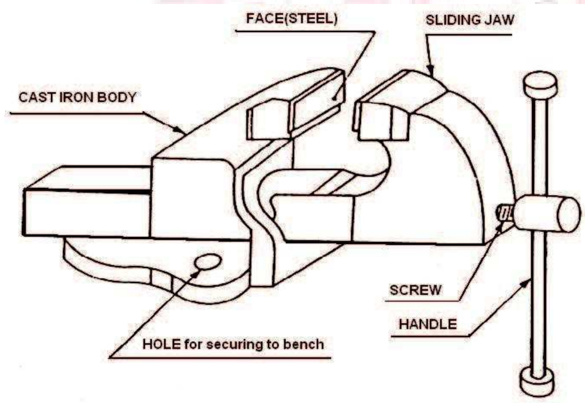


Figure: Bench Vice

It is fixed to the bench with bolts and nuts. The vice body consists of two main parts, fixed jaw and movable jaw. When the vice handle is turned in a clockwise direction, the sliding jaw forces the work against the fixed jaw. Jaw plates are made of hardened steel. Serrations on the jaws ensure a good grip. Jaw caps made of soft material are used to protect finished surfaces, gripped in the vice. The size of the vice is specified by the length of the jaws.

The vice body is made of cast Iron which is strong in compression, weak in tension and so fractures under shocks and therefore should never be hammered.

V –BLOCK:

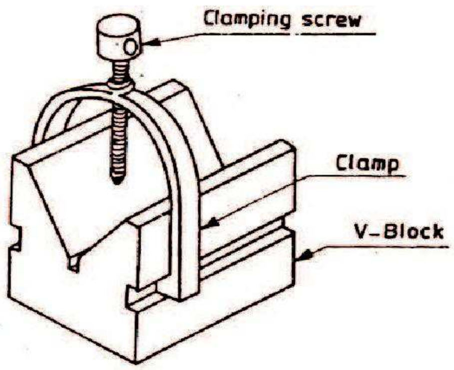
V block is rectangular or square block with a V groove on one or both sides opposite to each

other. The angle of the 'V' is usually 90^0. V block with a clamp is used to hold cylindrical work securely, during layout of measurement, for measuring operations or for drilling for this the bar is faced longitudinally in the V Groove and the screw of V clamp is tightened. This grip the rod is firm with its axis parallel to the axis of the v groove.

C-CLAMP:

This is used to hold work against an angle plate or v block or any other surface, when gripping is required.

Its fixed jaw is shaped like English alphabet 'C' and the movable jaw is round in shape and directly fitted to the threaded screw at the end .The working principle of this clamp is the same as that of the bench vice.



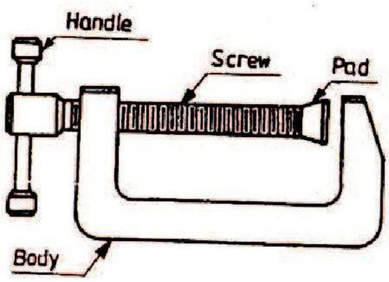


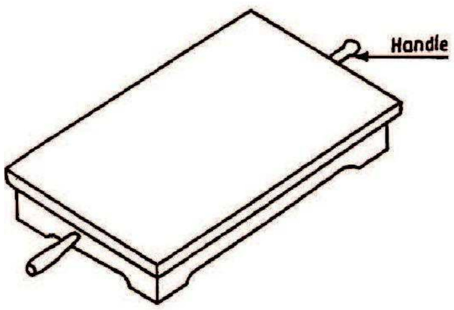
Figure: V block

Figure: C clamp

MARKING AND MEASURING TOOLS:

SURFACE PLATE:

The surface plate is machined to fine limits and is used for testing the flatness of the work piece. It is also used for marking out small box and is more precious than the marking table. The degree of the finished depends upon whether it is designed for bench work in a fitting shop or for using in an inspection room; the surface plate is made of Cast Iron, hardened Steel or Granite stone. It is specified by length, width, height and grade. Handles are provided on two opposite sides, to carry it while shifting from one place to another.



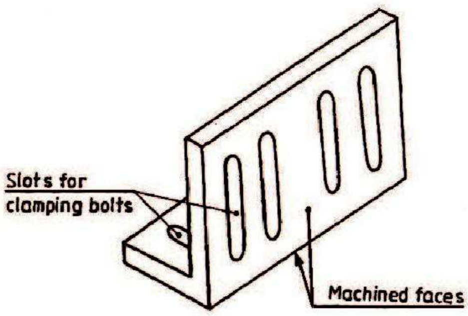


Figure: Surface plate

Figure: Angle plate

TRY-SQUARE:

It is measuring and marking tool for 90^0 angle .In practice, it is used for checking the squareness of many types of small works when extreme accuracy is not required .The blade of the Try square is made of hardened steel and the stock of cast Iron or steel. The size of the Try square is specified by the length of the blade.

SCRIBER:

A Scriber is a slender steel tool, used to scribe or mark lines on metal work pieces. It is made of hardened and tempered High Carbon Steel. The tip of the scriber is generally ground at $12^o$to 15^o. It is generally available in lengths, ranging from 125mm to 250mm .It has two pointed ends the bent end is used for marking lines where the straight end cannot reach.

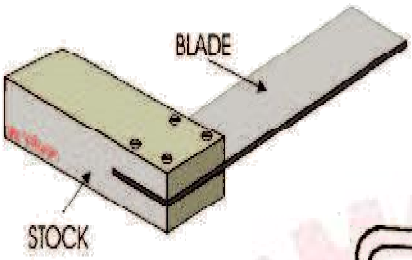


Figure: Try square

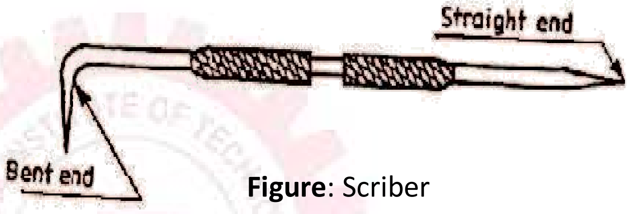


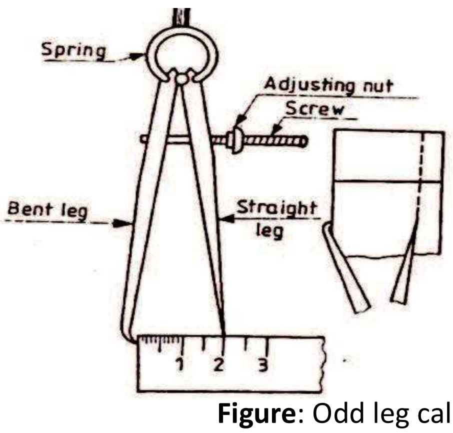
Figure: Scriber

ODD LEG CALIPER:

This is also called 'Jenny Caliper' or Hermaphrodite. This is used for marking parallel liners from a finished edge and also for locating the center of round bars; it has one leg pointed like a divider and the other leg bent like a caliper. It is specified by the length of the leg up to the hinge point.

DIVIDER:

It is basically similar to the calipers except that its legs are kept straight and pointed at the measuring edge. This is used for marking circles, arcs laying out perpendicular lines, by setting lines. It is made of case hardened mild steel or hardened and tempered low carbon steel. Its size is specified by the length of the leg**.**



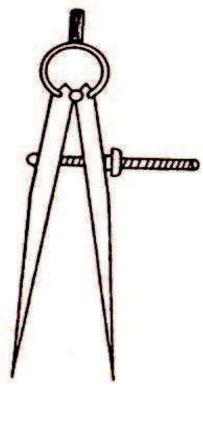


Figure: Odd leg caliper and divider

TRAMMEL:

Trammel is used for drawing large circles or arcs.

PUNCHES:

These are used for making indentations on the scribed lines, to make them visible clearly. These are made of high carbon steel. A punch is specified by its length and diameter (say as 150' 12.5mm). It consists of a cylindrical knurled body, which is plain for some length at the top of it. At the other end, it is ground to a point. The tapered point of the punch is hardened over a length of 20 to 30mm.

Dot punch is used to lightly indent along the layout lines, to locate center of holes and to provide a small center mark for divider point, etc. for this purpose, the punch is ground to a conical point having 60° included angle. *Center punch* is similar to the dot punch, except that it is ground to a conical point having 90° included angle. It is used to mark the location of the holes to be drilled.

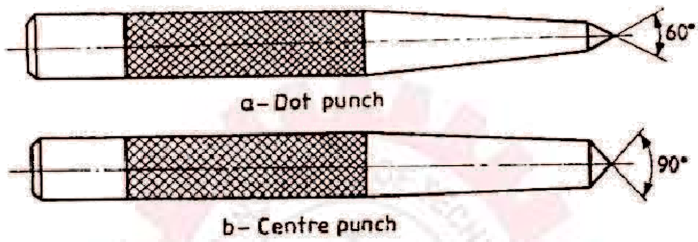


Figure: Punches

CALIPERS:

They are indirect measuring tools used to measure or transfer linear dimensions. These are used with the help of a steel Rule to check inside and outside measurements. These are made of Case hardened mild steel or hardened and tempered low carbon steel. While using, but the legs of the caliper are set against the surface of the work, whether inside or outside and the distance between the legs is measured with the help of a scale and the same can be transferred to another desired place. These are specified by the length of the leg. In the case of outside caliper, the legs are bent inwards and in the case of inside caliper, the legs bent outwards.

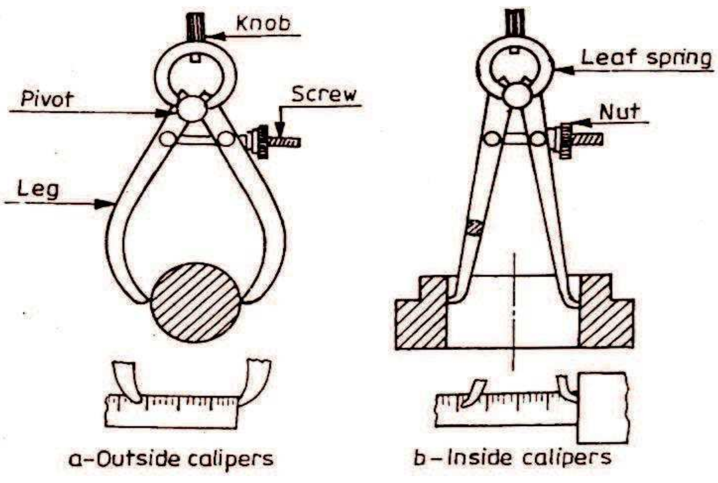


Figure: Calipers

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CUTTING TOOLS:

HACK SAW:

The Hack Saw is used for cutting metal by hand. It consists of a frame, which holds a thin blade, firmly in position. Hacksaw blade is specified by the number of teeth for centimeter. Hacksaw blades have a number of teeth ranging from 5 to 15 per centimeter (cm). Blades having lesser number of teeth per cm are used for cutting soft materials like aluminum, brass and bronze. Blades having larger number of teeth per centimeter are used for cutting hard materials like steel and cast Iron.

Hacksaw blades are classified as (i) All hard and (ii) flexible type. The all hard blades are made of H.S.S, hardened and tempered throughout to retain their cutting edges longer. These are used to cut hard metals. These blades are hard and brittle and can break easily by twisting and forcing them into the work while sawing.

Flexible blades are made of H.S.S or low alloy steel but only the teeth are hardened and the rest of the blade is soft and flexible. These are suitable for use by unskilled or semi skilled persons.

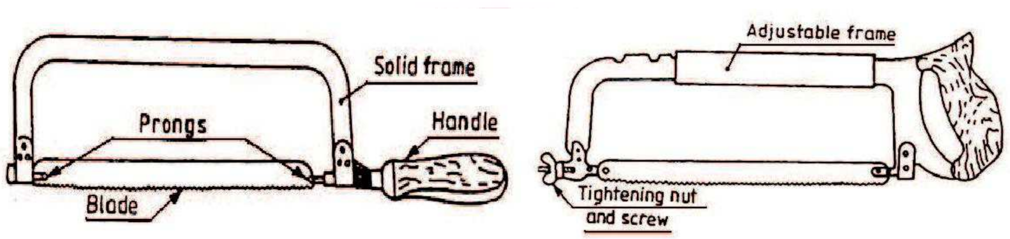

Figure: Hacksaw frame with blade

CHISELS:

Chisels are used for removing surplus metal or for cutting thin sheets. These tools are made from 0.9% to 1.0% carbon steel of octagonal or hexagonal section. Chisels are annealed, hardened and tempered to produce a tough shank and hard cutting edge. Annealing relieves the internal stresses in a metal. The cutting angle of the chisel for general purpose is about 60°.

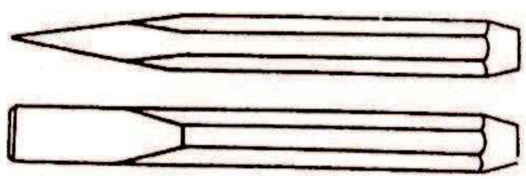

Figure: Flat chisel

TWIST DRILL:

Twist drills are used for making holes. These are made of High speed steel. Both straight and taper shank twist drills are used. The parallel shank twist drill can be held in an ordinary self – centering drill check. The tapper shank twist drill fits into a corresponding tapered bore provided in the drilling machine spindle.

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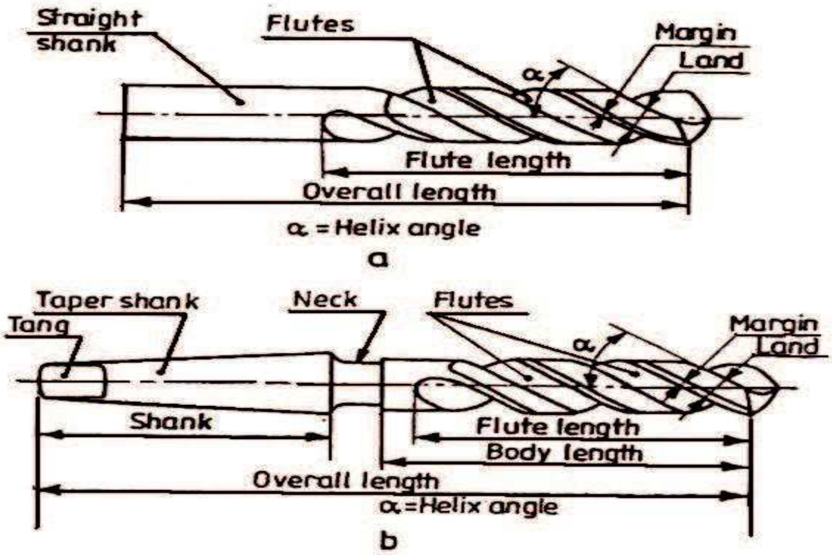

Figure: Twist drills

TAPS AND TAP WRENCHES:

A tap is a hardened and steel tool, used for cutting internal thread in a drill hole. Hand Taps are usually supplied in sets of three in each diameter and thread size. Each set consists of a tapper tap, intermediate tap and plug or bottoming tap. Taps are made of high carbon steel or high speed steel.

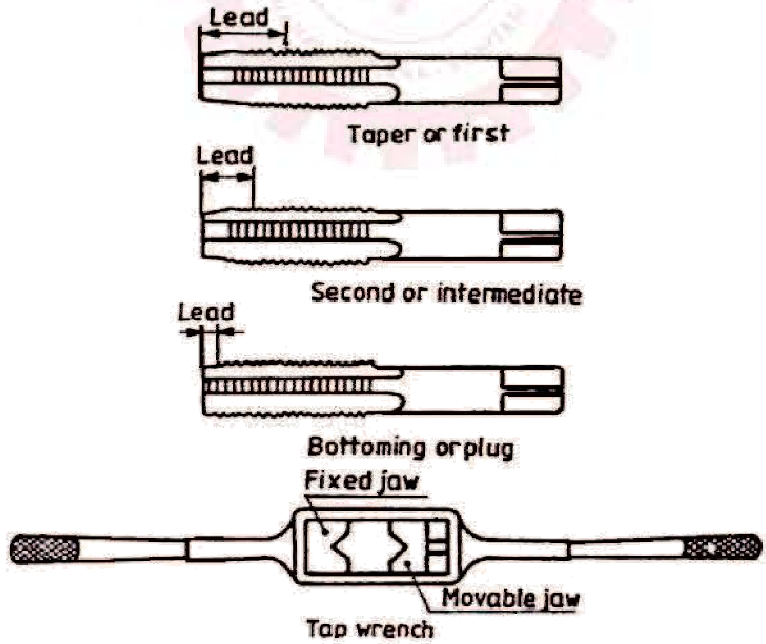

Figure: Taps and tap wrench

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DIES AND DIE HOLDERS:

Dies are the cutting tools used for making external thread. Dies are made either solid or split type. They are fixed in a die stock for holding and adjusting the die gap. They are made of Steel or High Carbon Steel.

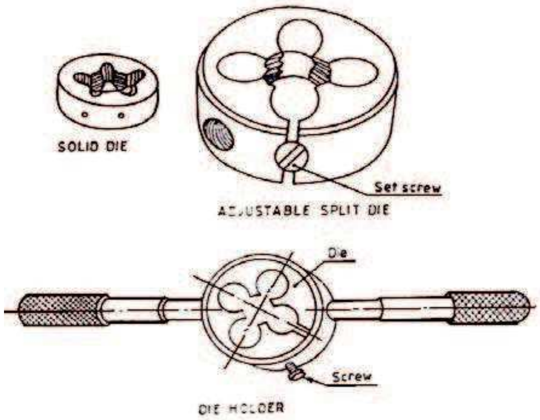


Figure: Dies and die holder

BENCH DRILLING MACHINE:

Holes are drilled for fastening parts with rivets, bolts or for producing internal thread. Bench drilling machine is the most versatile machine used in a fitting shop for the purpose. Twist drills, made of tool steel or high speed steel are used with the drilling machine for drilling holes.

Following are the stages in drilling work

1. Select the correct size drills, put it into the check and lock it firmly

2. Adjust the speed of the machine to suit the work by changing the belt on the pulleys. Use high speed for small drills and soft materials and low speed for large diameter drills and hard materials.

3. Layout of the location of the pole and mark it with a center punch.

4. Hold the work firmly in the vice on the machine table and clamp it directly on to the machine table.

5. Put on the power, locate the punch mark and apply slight pressure with the Feed Handle.

6. Once Drilling is commenced at the correct location, apply enough pressure and continue drilling. When drilling steel apply cutting oil at the drilling point.

7. Release the pressure slightly, when the drill point pierces the lower surface of the metal. This prevents the drill catching and damaging the work or drill.

8. On completion of drilling retrace the drill out of the work and put off the power supply.

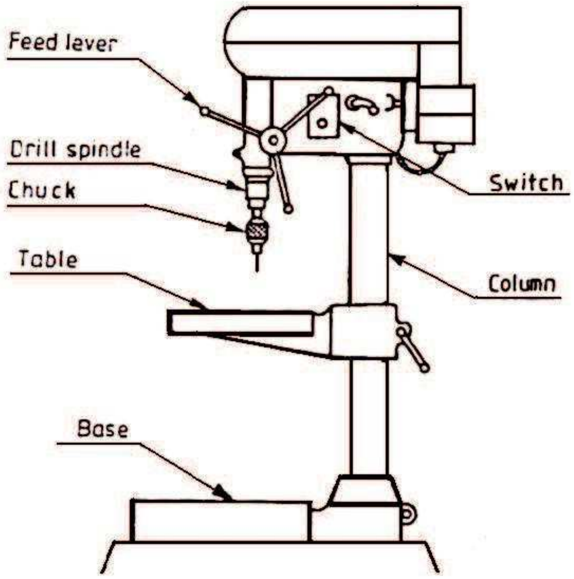


Figure: Bench drill

FINISHING TOOLS:

REAMERS:

Reaming is an operation of sizing and finishing a drilled hole, with the help of a cutting tool called reamer having a number of cutting edges. For this, a hole is first drilled, the size of which is slightly smaller than the finished size and then a hand reamer or machine reamer is used for finishing the hole to the correct size.

Hand Reamer is made of High Carbon Steel and has left hand spiral flutes so that, it is prevented from screwing into the whole during operation. The Shank end of the reamer is made straight so that it can be held in a tap wrench. It is operated by hand, with a tap wrench fitted on the square end of the reamer and with the work piece held in the vice. The body of the reamer is given a slight tapper at its working end, for its easy entry into the whole during operation, it is rotated only in clock wise direction and also while removing it from the whole.

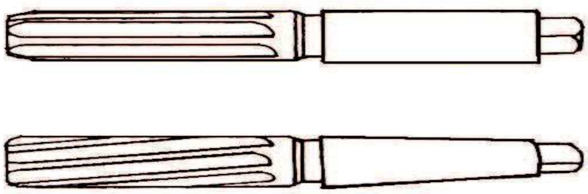


Figure: Reamers

FILES:

Filing is one of the methods of removing small amounts of material from the surface of a metal part. A file is hardened steel too, having small parallel rows of cutting edges or teeth on its surfaces.

On the faces, the teeth are usually diagonal to the edge. One end of the file is shaped to fit into a wooden handle. The figure shows various parts of a hand file. The hand file is parallel in width and tapering slightly in thickness, towards the tip. It is provided with double cut teeth. On the faces, single cut on one edge and no teeth on the other edge which is known as a safe edge.

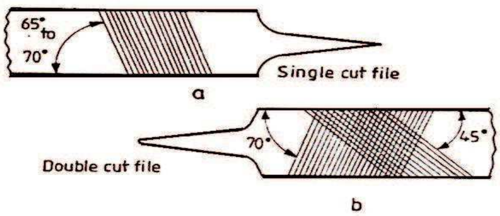


Figure: Parts of a hand file

Files are classified according to their shape, cutting teeth and pitch or grade of the teeth. The figure shows the various types of files based on their shape.

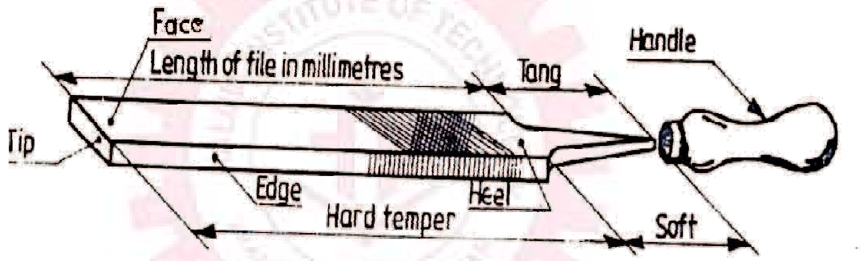
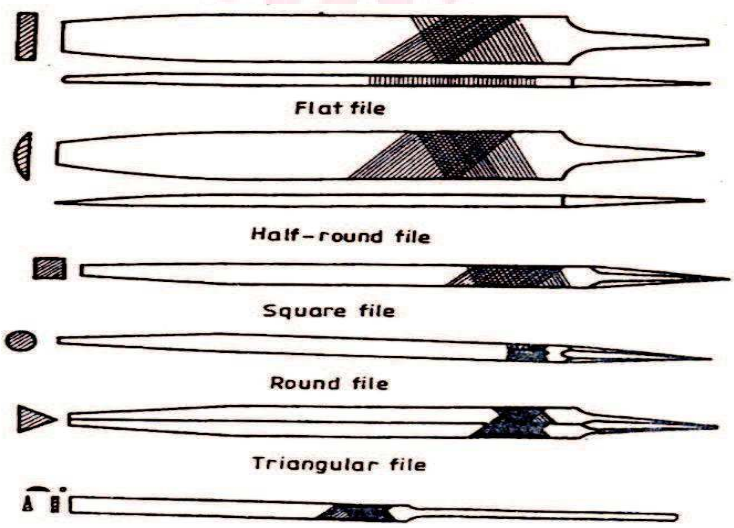


Figure: Single and double cut files



Needle file
Figure: Types of files

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MISCELLANEOUS TOOLS:

FILE CARD:

It is a metal brush, used for cleaning the files, to free them from filings, clogged in-between the teeth.

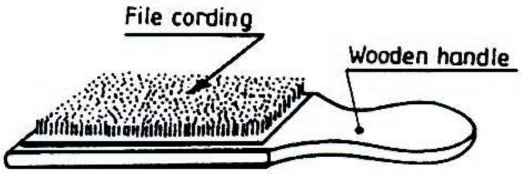


Figure: File card

SPIRIT LEVEL:

It is used to check the leveling of machines.

HAMMER:

Hammer is a striking tool which is used to apply force on any hand cutting tool for cutting, chipping, marking and producing impressions. Hammers are specified on the basis of their weight and size of the peen. Generally hammers are made of carbon steel having percentage of carbon of 0.8 – 1. Hammers are categorized as:- ball peen, cross peen and straight peen hammers.

BALL PEEN HAMMER:

Ball- Peen Hammers are named, depending upon their shape and material and specified by their weight. A ball peen hammer has a flat face which is used for general work and a ball end, particularly used for riveting.

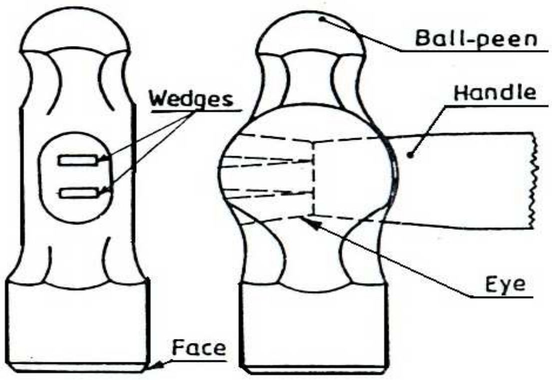


Figure: Ball peen hammer

CROSS-PEEN HAMMER:

It is similar to ball peen hammer, except the shape of the peen. This is used for chipping, riveting, bending and stretching metals and hammering inside the curves and shoulders.

STRAIGHT-PEEN HAMMER:

This is similar to cross peen hammer, but its peen is in-line with the hammer handle. It is used for swaging, riveting in restricted places and stretching metals.

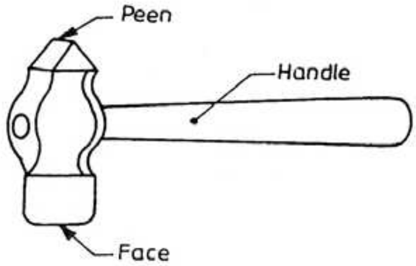


Figure: Cross peen hammer Figure

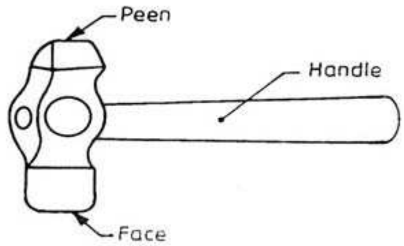


Figure: Straight peen hammer

SCREW DRIVER:

A screw driver is designed to turn screws. The blade is made of steel and is available in different lengths and diameters. The grinding of the tip to the correct shape is very important. A star screw driver is specially designed to fit the head of star screws. The end of the blade is fluted instead of flattened. The screw driver is specified by the length of the metal part from handle to the tip.

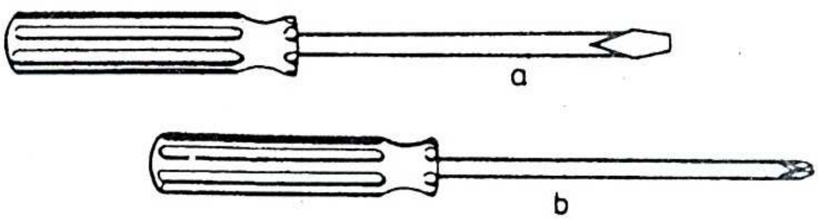


Figure: Screw drivers

SAFE PRACTICE:

The following are some of the safe and correct work practices in bench work and fitting shop with respect to the tools used

1. Keep hands and tools wiped clean and free of dirt, oil and grease. Dry tools are safer to use than slippery tools.

2. Do not carry sharp tools on pockets.

3. Wear leather shoes and not sandals.

4. Don’t wear loose clothes.

5. Do not keep working tools at the edge of the table.

6. Position the work piece such that the cut to be made is close to the vice. This practice prevents springing, saw breakage and personal injury.

7. Apply force only on the forward (cutting) stroke and relieve the force on the return stroke while sawing and filing.

8. Do not hold the work piece in hand while cutting.

9. Use the file with a properly fitted tight handle.

10. After filing, remove the burrs from the edges of the work, to prevent cuts to the fingers.

11. Do not use vice as an anvil.

12. While sawing, keep the blade straight; otherwise it will break

13. Do not use a file without handle.

14. Clean the vice after use.

LABORATORY EXERCISE_1

FITTING

AIM: To make V- fit from the given two MS plates and drilling and Tapping as shown in figure.

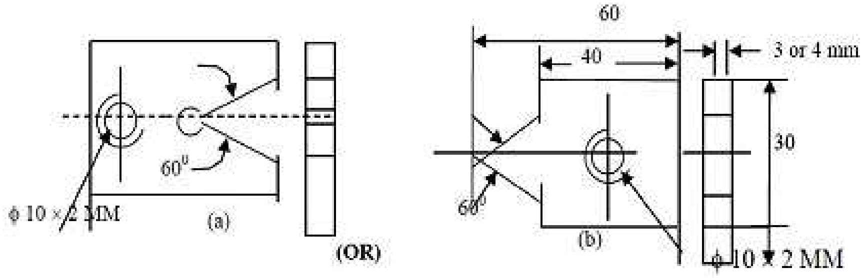


Fig.1: Job for fitting practice

THEORY:

Machine tools are capable of producing work at a faster rate, but, there are occasions when components are processed at the bench. Sometimes, it becomes necessary to replace or repair component which must be fit accurately with another component on reassembly. This involves a certain amount of hand fitting. The assembly of machine tools, jigs, gauges, etc, involves certain amount of bench work. The accuracy of work done depends upon the experience and skill of the fitter.

The term 'bench work' refers to the production of components by hand on the bench, where as fitting deals which the assembly of mating parts, through removal of metal, to obtain the required fit.

Both the bench work and fitting requires the use of number of simple hand tools and considerable manual efforts. The operations in the above works consist of filing, chipping, scraping, sawing drilling, and tapping.

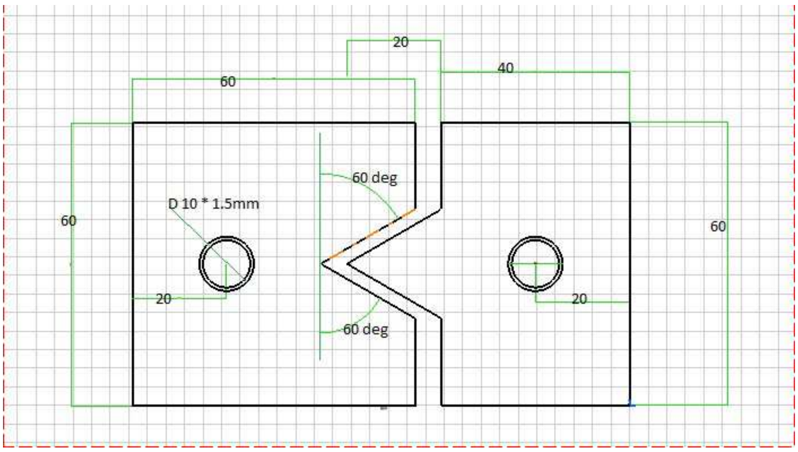
TOOLS REQUIRED:

Bench vice, set of Files, Try-square, Scriber, Steel rule, Ball-peen hammer, Dot punch, Hacksaw, Vernier caliper, Surface plate, Angle plate, 5mm drill bit, 3mm drill bit, M6 tap set with wrench, Anvil and Drilling machine.

SEQUENCE OF OPERATIONS:

1. The burrs in the pieces are removed and the dimensions are checked with steel rule.
2. Make both pieces surface levels and right angles by fixing in the Vice, use Files for removing material to get level.
3. With the help of Try square check the right angles and surface levels.
4. Using Surface plate and Angle plate mark the given two metal pieces as per drawing with steel rule and odd leg caliper.
5. Punch the scribed lines with dot punch and hammer keeping on the Anvil. Punch to punch gives 5 mm gap.
6. Cut excess material wherever necessary with Hacksaw frame with blade.
7. The corners and flat surfaces are filed by using square/flat and triangular file to get the sharp corners.
8. Now a hole of diameter 8.5 mm is drilled by a manual drilling machine.
9. An internal thread is produced with the help of tap and tape wrench on the drilled hole.
8. Dimensions are checked by vernier caliper and match the two pieces. Any defect noticed, are rectified by filing with a smooth file.
9. Care is taken to see that the punched dots are not crossed, which is indicated by the half of the punch dots left on the pieces.

RESULT:



The required V- fitting is thus obtained, by following the stages, as described above.

MACHINING PROCESSES

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DEPARTMENT OF MECHANICAL ENGINEERING

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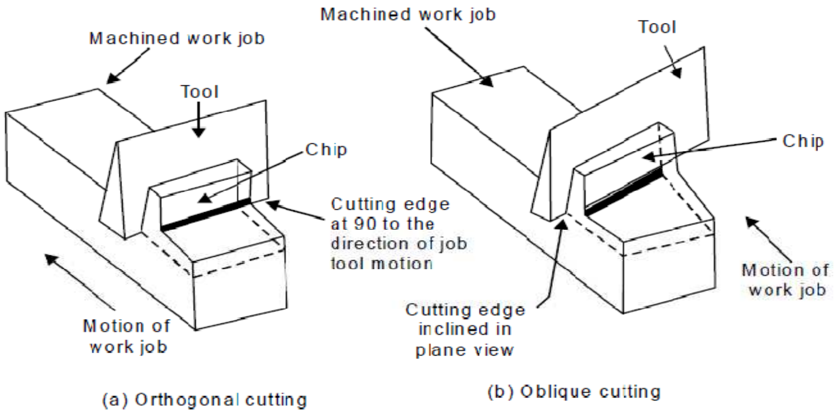
MACHINING PROCESSES - INTRODUCTION:

Metal cutting or traditional machining processes are also known as conventional machining processes. These processes are commonly carried out in machine shops or tool room for machining cylindrical or flat jobs to a desired shape, size and finish on a rough block of job material with the help of a wedge shaped tool. General metal cutting operations are shown in the below figure-

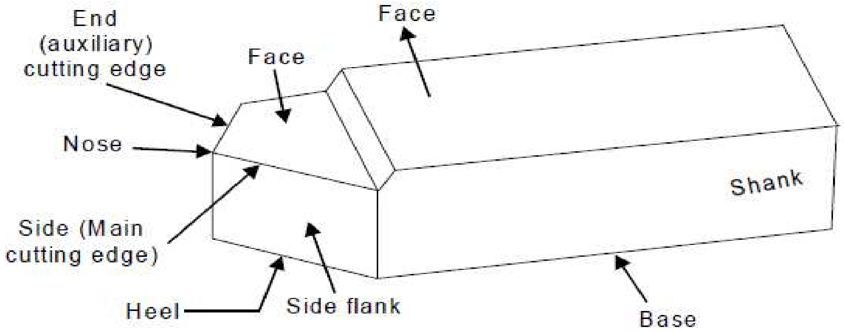


Cutting tools performs the main machining operation. They comprise of single point cutting tool or multipoint cutting tools. It is a body having teeth or cutting edges on it. A single point cutting tool (such as a lathe, shaper and planner and boring tool) has only one cutting edge, whereas a multi-point cutting tool (such as milling cutter, milling cutter, drill, reamer and broach) has a number of teeth or cutting edges on its periphery.

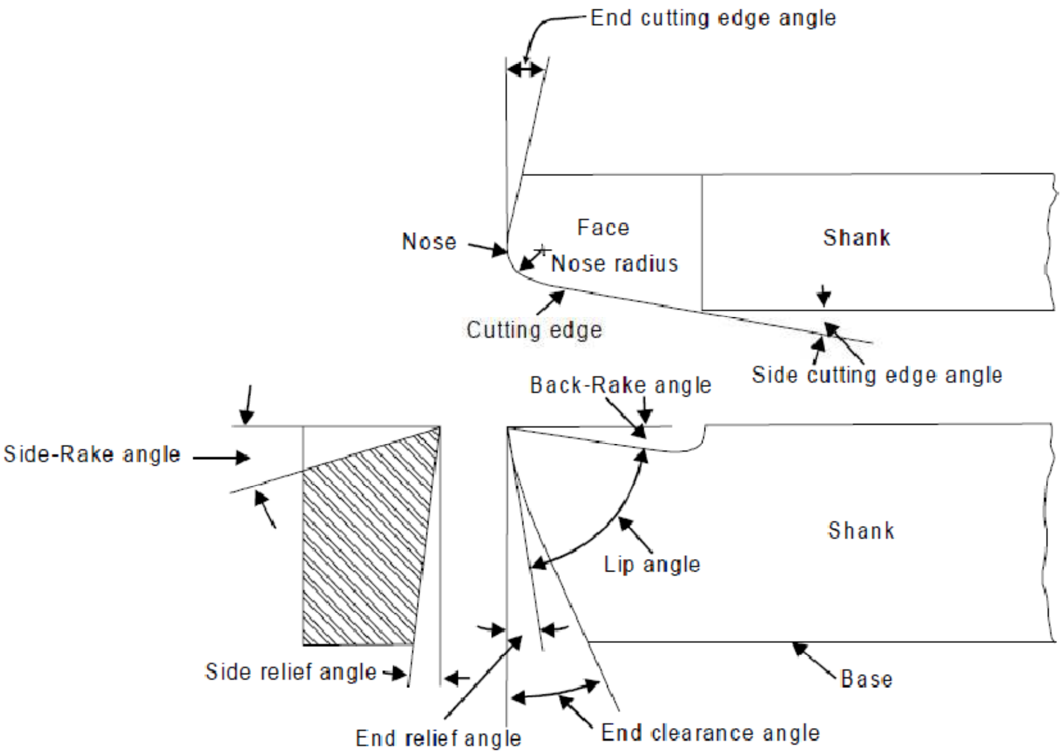
A cutting tool made of a much harder material than the material of the part to be machined. Cutting tools are made of material which can be hardened by suitable heat treatment. During machining, lot of heat is generated and the temperature of the cutting edge of the tool may reach 650–700°C. The tool must maintain its hardness even at such elevated temperatures. This property of retaining its hardness at elevated temperatures is called 'red hardness'. Cutting tools develop the property of red-hardness due to addition of tungsten and molybdenum to high carbon steel. These days, cutting tools are made of high speed steel, or tungsten carbide. Tools made of ceramic materials (like Al2O3, SiC), and polycrystalline diamonds are also used for special applications.

High speed steels (18:4:1) are most commonly operated as cutting tools at much higher speed i.e. twice or thrice where as tool steel. It is the most common kind of cutting tool. It contains 18% tungsten, 4% chromium and 1 % vanadium, 0.8 carbon and remaining iron. **Chromium** improves corrosion resistance. **Tungsten** increases hardness, wear resistance, shocks resistance and magnetic reluctance and **Vanadium** improves tensile strength, elastic limit, ductility, fatigue resistance, shock resistance and response to heat treatment.

GEOMETRY OF SINGLE POINT CUTTING TOOL:



NOMENCLATURE SINGLE POINT TOOL:



(i) BACK RAKE ANGLE:

It is the angle between the face of the tool and a line parallel with base of the tool measured in a perpendicular plane through the side cutting edge. If the slope face is downward toward the nose, it is negative back rake angle and if it is upward toward nose, it is positive back rake angle. This angle helps in removing the chips away from the work piece.

(ii) SIDE RAKE ANGLE:

It is the angle by which the face of tool is inclined sideways. This angle of tool determines the thickness of the tool behind the cutting edge. It is provided on tool to provide clearance between work piece and

tool so as to prevent the rubbing of work- piece with end flake of tool. It is the angle between the surface the flank immediately below the point and the line down from the point perpendicular to the base.

(iii) END RELIEF ANGLE:

It is the angle that allows the tool to cut without rubbing on the work- piece. It is defined as the angle between the portion of the end flank immediately below the cutting edge and a line perpendicular to the base of the tool, measured at right angles to the flank. Some time extra end clearance is also provided on the tool that is also known as end clearance angle. It is the secondary angle directly below the end relief angle.

(iv) SIDE RELIEF ANGLE:

It is the angle that prevents the interference as the tool enters the material. It is the angle between the portion of the side flank immediately below the side edge and a line perpendicular to the base of the tool measured at right angles to the side. It is incorporated on the tool to provide relief between its flank and the work piece surface. Some time extra side clearance is also provided on the tool that is also known as side clearance angle. It is the secondary angle directly below the side relief angle.

(v) END CUTTING EDGE ANGLE:

It is the angle between the end cutting edge and a line perpendicular to the shank of the tool. It provides clearance between tool cutting edge and work piece.

(vi) SIDE CUTTING EDGE ANGLE:

It is the angle between straight cutting edge on the side of tool and the side of the shank. It is also known as lead angle. It is responsible for turning the chip away from the finished surface.

(vii) NOSE RADIUS:

It is the nose point connecting the side cutting edge and end cutting edge. It possesses small radius which is responsible for generating surface finish on the work-piece

LATHE- INTRODUCTION:

In a machine shop, metals are cut to shape on different machine tools. A lathe is used to cut and shape the metal by revolving the work against a cutting tool. The work is clamped either in a chuck, fitted on to the lathe spindle or in-between the centers. The cutting tool is fixed in a tool post, mounted on a movable carriage that is positioned on the lathe bed. The cutting tool can be fed on to the work, either lengthwise or cross-wise. While turning, the chuck rotates in counter-clockwise direction, when viewed from the tail stock end.

PRINCIPAL PARTS OF A LATHE:

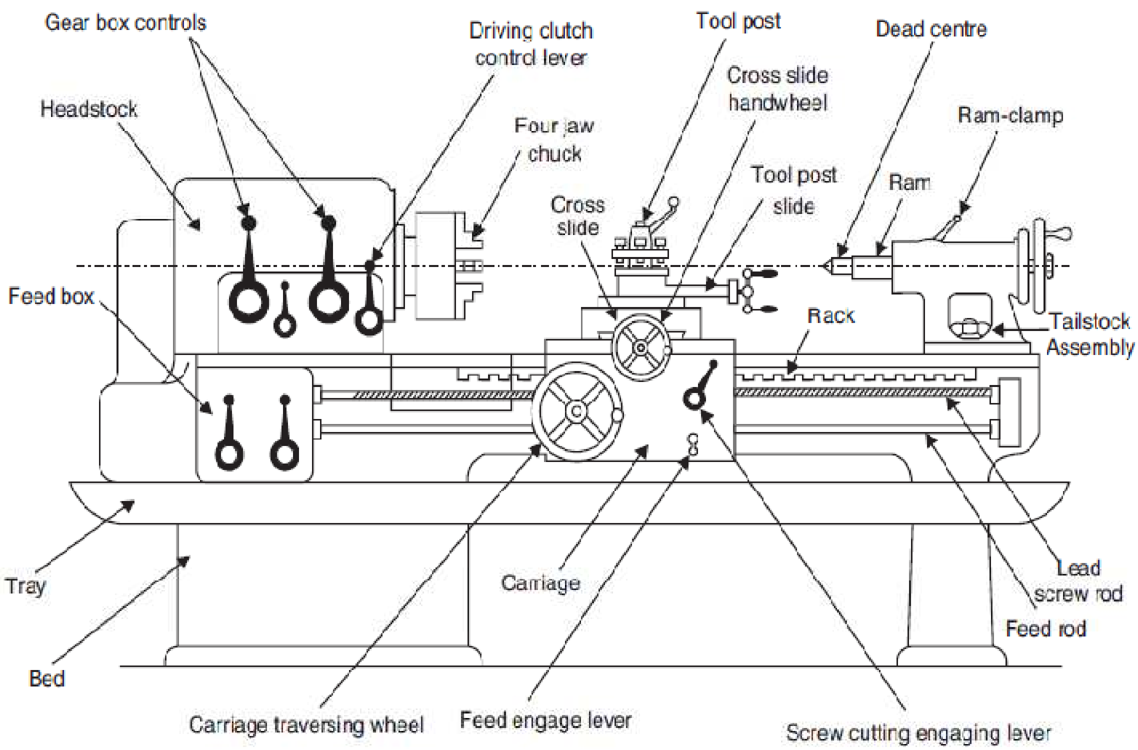


Figure: Parts of a center Lathe

Above figure shows a center lathe, indicating the main parts. The name is due to the fact that work pieces are held by the centers.

1. BED:

It is an essential part of a lathe, which must be strong and rigid. It carries all parts of the machine and resists the cutting forces. The carriage and the tail stock move along the guide ways provided on the bed. It is usually made of cast iron.

2. HEAD STOCK:

It contains either a cone pulley or gearings to provide the necessary range of speeds and feeds. It contains the main spindle, to which the work is held and rotated.

3. TAIL STOCK:

It is used to support the right hand end of a long work piece. It may be clamped in any position along the lathe bed. The tail stock spindle has an internal Morse taper to receive the dead center that supports the work. Drills, reamers, taps may also be fitted into the spindle, for performing operations such as drilling, reaming and tapping.

4. CARRIAGE OR SADDLE:

It is used to control the movement of the cutting tool. The carriage assembly consists of the longitudinal slide, cross slide and the compound slide and apron. The cross slide moves across the length of the bed and perpendicular to the axis of the spindle. This movement is used for facing and to provide the necessary depth of cut while turning. The apron, which is bolted to the saddle, is on the front of the lathe and contains the longitudinal and cross slide controls. This movement is controlled by manually operating the hand traversing wheel. It can also be imparted this traversing motion at different speeds automatically by engaging into the **Feed Rod or Feed Shaft.**

5. COMPOUND REST:

It supports the tool post. By swiveling the compound rest on the cross slide, short tapers may be turned to any desired angles.

6. TOOL POST:

The tool post holds the tool holder or the tool, which may be adjusted to any working position.

7. LEAD SCREW:

It is a long threaded shaft, located in front of the carriage, running from the head-stock to the tail stock. It is geared to the spindle and controls the movement of the tool, either for automatic feeding or for cutting threads. The half nut or split nut is used for thread cutting in a lathe. It engages or disengages the carriage with the lead screw so that the rotation of the lead screw is used to traverse the tool along the work piece to cut screw threads.

8. CENTERS:

There are two centers known as dead center and live center. The dead center is positioned in the tail stock spindle and the live center, in the head-stock spindle. While turning between centers, the dead center does not revolve with the work while the live center revolves with the work.

WORK-HOLDING DEVICES:

1. THREE JAW CHUCK:

It is a work holding device having three jaws (self-centering) which will close or open with respect to the chuck center or the spindle center, as shown in figure. It is used for holding regular objects like round bars, hexagonal rods, etc.

2. FOUR JAW CHUCK:

A four jaws chuck is for clamping irregularly shaped jobs. In 4-jaws chuck each jaw moves in radially independent of other jaws. Centering means that the centre line of the work piece should nearly coincide with centre line of machine spindle. It is not enough to hold the job centrally in the chuck, the portion of work piece projecting out of chuck should also be centrally placed.

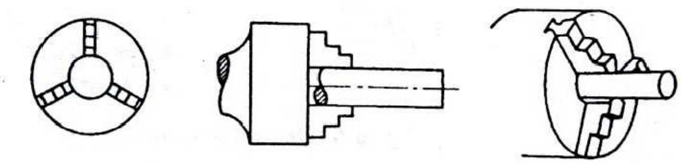


Figure: Three jaw chuck

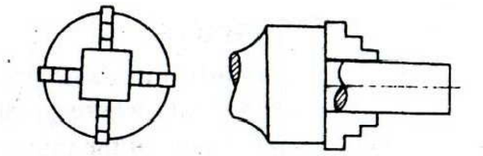


Figure: Four jaw chuck

3. FACE PLATE:

It is a plate of large diameter, used for turning operations. Certain types of work that cannot be held in chucks are held on the face plate with the help of various accessories.

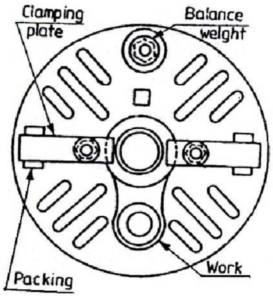


Figure: Face plate

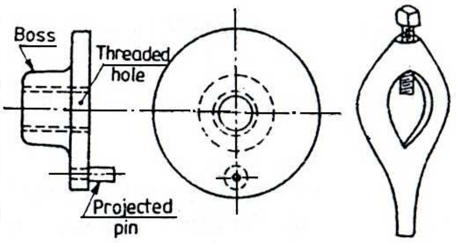


Figure: Lathe dog and driving plate

4. LATHE DOGS AND DRIVING PLATE:

These are used to drive a work piece that is held between centers. These are provided with an opening to receive and clamp the work piece and dog tail, the tail of the dog is carried by the pin provided in the driving plate for driving the work piece.

LATHE OPERATIONS:

1. TURNING:

Cylindrical shapes, both external and internal, are produced by turning operation. Turning is the process in which the material is removed by a traversing cutting tool, from the surface of a rotating work piece. The operation used for machining internal surfaces is often called the boring operation in which a hole previously drilled is enlarged. For turning long work, first it should be faced and center drilled at one end and then supported by means of the tail-stock centre.

2. BORING:

Boring is enlarging a hole and is used when correct size drill is not available. However, it should be noted that boring cannot make a hole.

3. FACING:

Facing is a machining operation, performed to make the end surface of the work piece, flat and perpendicular to the axis of rotation. For this, the work piece may be held in a chuck and rotated about the lathe axis. A facing tool is fed perpendicular to the axis of the lathe. The tool is slightly inclined towards the end of the work piece.

4. TAPER TURNING:

A taper is defined as the uniform change in the diameter of a work piece, measured along its length. It is expressed as a ratio of the difference in diameters to the length. It is also expressed in degrees of half the included (taper) angle. Taper turning refers to the production of a conical surface, on the work piece on a lathe. Short steep tapers may be cut on a lathe by swiveling the *compound rest* to the required angle. Here, the cutting tool is fed by means of the compound slide feed handle. The work piece is rotated in a chuck or face plate or between centers.

5. DRILLING:

Holes that are axially located in cylindrical parts are produced by drilling operation, using a twist drill. For this, the work piece is rotated in a chuck or face plate. The tail stock spindle has a standard taper. The drill bit is fitted into the tail stock spindle directly or through drill chuck. The tail stock is then moved over the bed and clamped on it near the work. When the job rotates, the drill bit is fed into the work by turning the tail stock hand wheel.

6. KNURLING:

It is the process of embossing a diamond shaped regular pattern on the surface of a work piece using a special knurling tool. This tool consists of a set of hardened steel rollers in a holder with the teeth cut on their surface in a definite pattern. The tool is held rigidly on the tool post and the rollers are pressed against the revolving work piece to squeeze the metal against the multiple cutting edges. The purpose of knurling is to provide an effective gripping surface on a work piece to prevent it from slipping when operated by hand.

7. CHAMFERING:

It is the operation of beveling the extreme end of a work piece. Chamfer is provided for better look, to enable nut to pass freely on threaded work piece, to remove burrs and protect the end of the work piece from being damaged.

8. THREADING:

Threading is nothing but cutting helical groove on a work piece. Threads may be cut either on the internal or external cylindrical surfaces. A specially shaped cutting tool, known as thread cutting tool, is used for this purpose. Thread cutting in a lathe is performed by traversing the cutting tool at a definite rate, in proportion to the rate at which the work revolves.

All the operations of Lathe are shown in the following figures:-

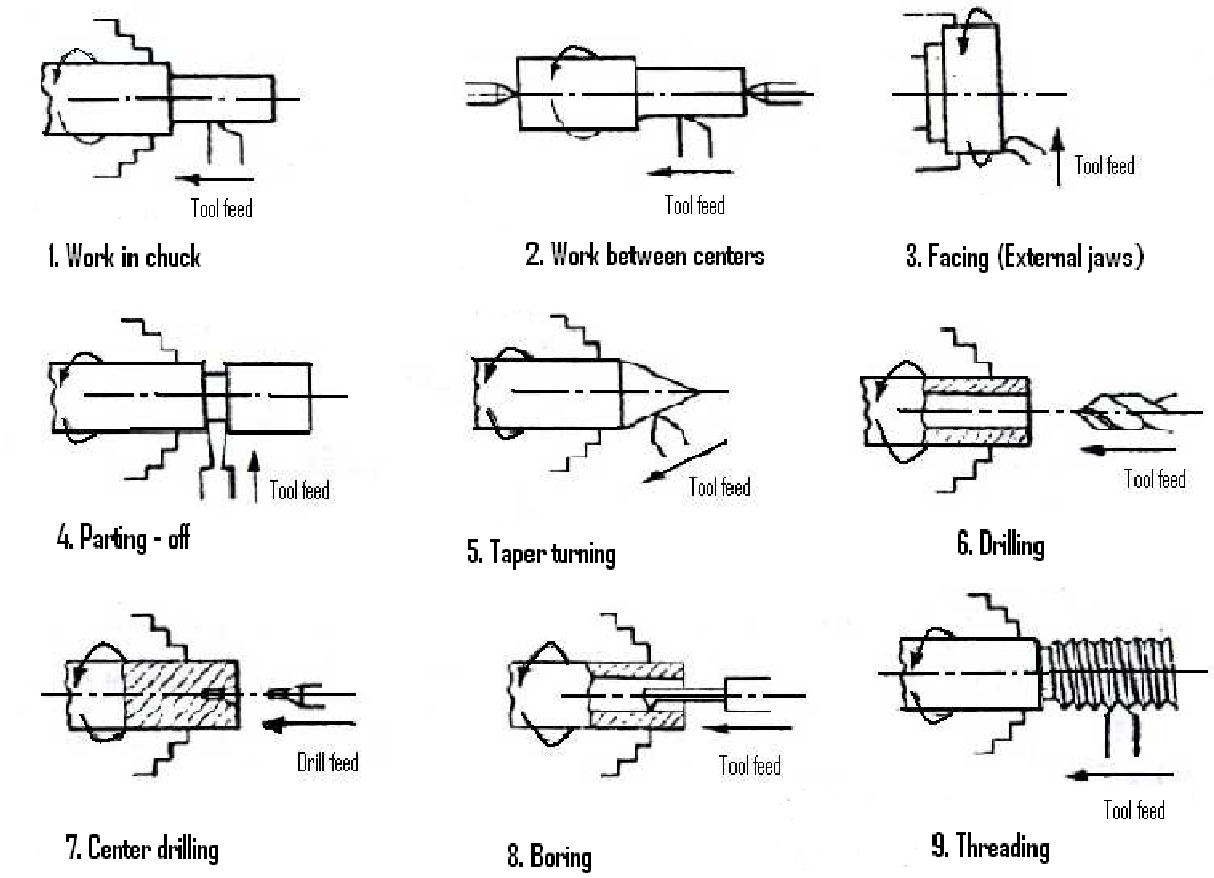


Figure: Operations of Lathe

SAFETY PRECAUTIONS:

1. Always wear eye protection - preferably industrial quality safety glasses with side-shields. The lathe can throw off sharp, hot metal chips at considerable speed as well as spin off spirals of metal that can be quite hazardous. Don't take chances with your eyes.

2. Wear short sleeve shirts, loose sleeves can catch on rotating work and quickly pull your hand or arm into harm's way.

3. Wear shoes - preferably leather work shoes - to protect your feet from sharp metal chips on the shop floor and from tools and chunks of metal that may get dropped.

4. Remove wrist watches, necklaces, chains and other jewelry. Tie back long hair so it can't get caught in the rotating work. Think about what happens to your face if your hair gets entangled.

5. Always double check to make sure your work is securely clamped in the chuck or between centers before starting the lathe. Start the lathe at low speed and increase the speed gradually.

6. Get in the habit of removing the chuck key immediately after use. Some users recommend never removing your hand from the chuck key when it is in the chuck. The chuck key can be a lethal projectile if the lathe is started with the chuck key in the chuck.

7. Keep your fingers clear of the rotating work and cutting tools. This sounds obvious, but I am often tempted to break away metal spirals as they form at the cutting tool.

8. Avoid reaching over the spinning chuck. For filing operations, hold the tang end of the file in your left hand so that your hand and arm are not above the spinning chuck.

9. Never use a file with a bare tang - the tang could be forced back into your wrist or palm.

LABORATORY EXERCISE_1

LATHE

AIM: To prepare a job on lathe involving facing, outside turning, taper turning, step turning, radius making and parting off.

TOOLS AND MATERIALS REQUIRED:

SEQUENCE OF OPERATIONS:

RESULT:

PRECAUTIONS:

SHAPER- INTRODUCTION:

The shaper (also called shaping machine) is a reciprocating type of machine tool used for producing small flat surfaces with the help of a single point tool reciprocating over the stationary work piece. The flat surface may be horizontal, inclined or vertical. The reciprocating motion of the tool is obtained either by the crank and slotted lever quick return motion mechanism or Whitworth quick return motion mechanism.

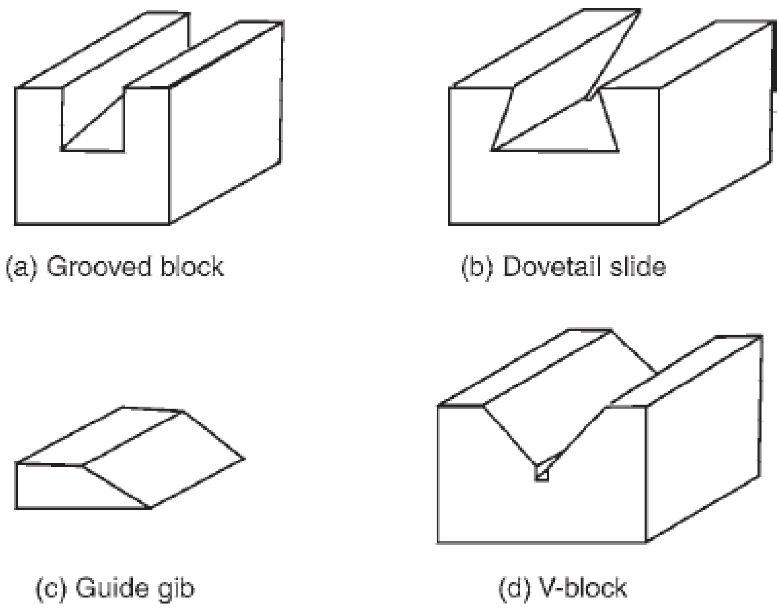


Fig.: Parts produced on a shaper

PRINCIPAL PARTS OF A SHAPER:

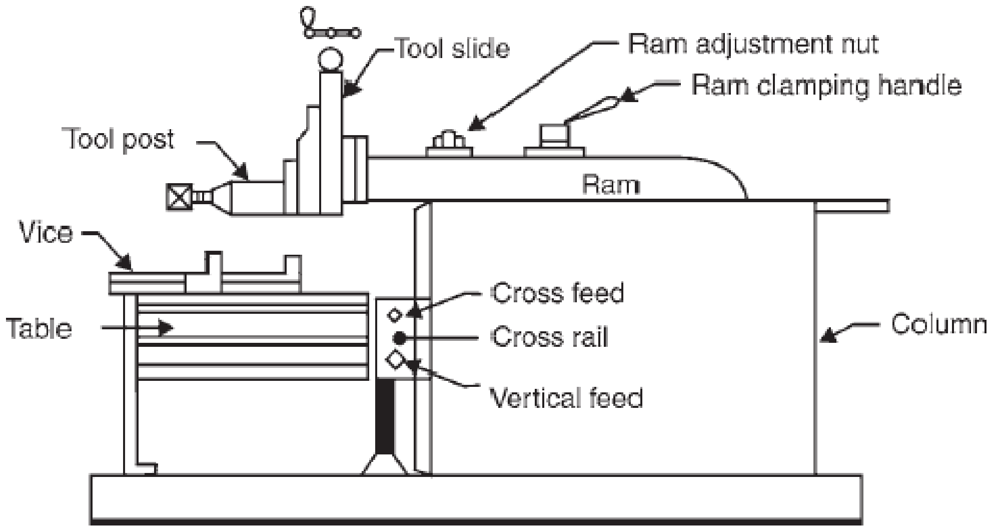


Fig.: Principal Parts of a Shaper

The principal parts of a shaper, as shown in the previous Figures are as follows:

1. BASE:

It is a heavy structure of cast iron which supports other parts of a shaper.

2. COLUMN:

It is a box-like structure made up of cast iron and mounted upon the base. It contains the driving mechanism and is provided with two machined guide ways on the top of it on which the ram reciprocates.

3. RAM:

It is a reciprocating member which reciprocates on the guide ways provided above the column. It carries a tool-slide on its head and a mechanism for adjusting the stroke length.

4. TOOL HEAD:

It is attached to the front portion of the ram with the help of a nut and a bolt. It is used to hold the tool rigidly; it also provides the vertical and angular movements to the tool for cutting.

5. CROSS-RAIL:

It is attached to the front vertical portion of the column. It is used for the following two purposes:

(*a*) It helps in elevating the table over the column in the upward direction, and

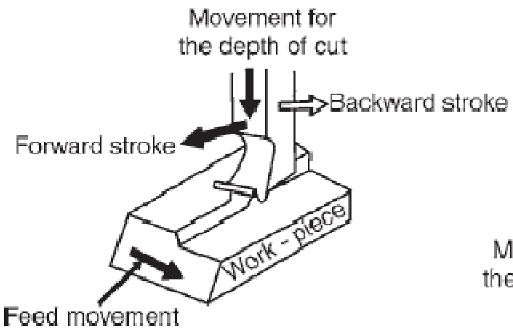
(*b*) The table can be moved in a direction perpendicular to the axis of the ram over this cross rail.

6. TABLE:

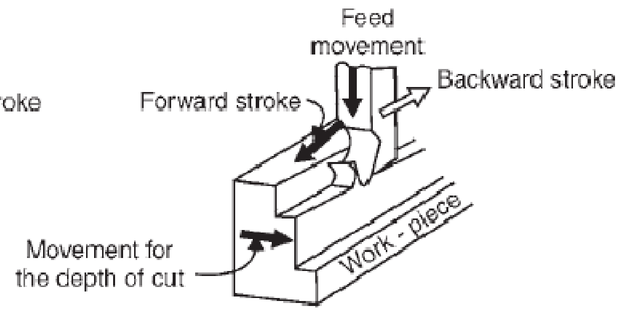
It is used for holding the work piece. It can be adjusted horizontally and vertically with the help of spindles.

WORKING PRINCIPLE AND OPERATION OF A SHAPER:

We have already discussed that in a shaper, a single point cutting tool reciprocates over the stationary work piece. The tool is held in the tool post of the reciprocating ram and performs the cutting operation during its forward stroke. It may be noted that during the backward stroke of the ram, the tool does not remove material from the work piece. Both these strokes (i.e., forward and backward strokes) form one working cycle of the shaper. For shaping in horizontal direction, as shown in Fig. (a). the clamped work piece is fed against the reciprocating tool after every cutting cycle. The depth of cut is adjusted by moving the tool downward towards the work piece. For shaping in vertical direction, as shown in Fig. (b). the tool is fed vertically towards the work piece after every cutting cycle. The depth of cut is adjusted by moving the work piece sideways.



(a) Shaping in Horizontal Direction



(b) Shaping in Vertical Direction

Fig.: Working Principle and Operation of a Shaper

SHAPER MECHANISM:

In a shaper, rotary motion of the drive is converted into reciprocating motion of the ram by the mechanism housed within the column or the machine. In a standard shaper metal is removed in the forward cutting stroke, while the return stroke goes idle and no metal is removed during this period. The shaper mechanism is so designed that it moves the ram holding the tool at a comparatively slower speed during forward cutting stroke, whereas during the return stroke it allow the ram to move at a faster speed to reduce the idle return time. This mechanism is known as quick return mechanism.

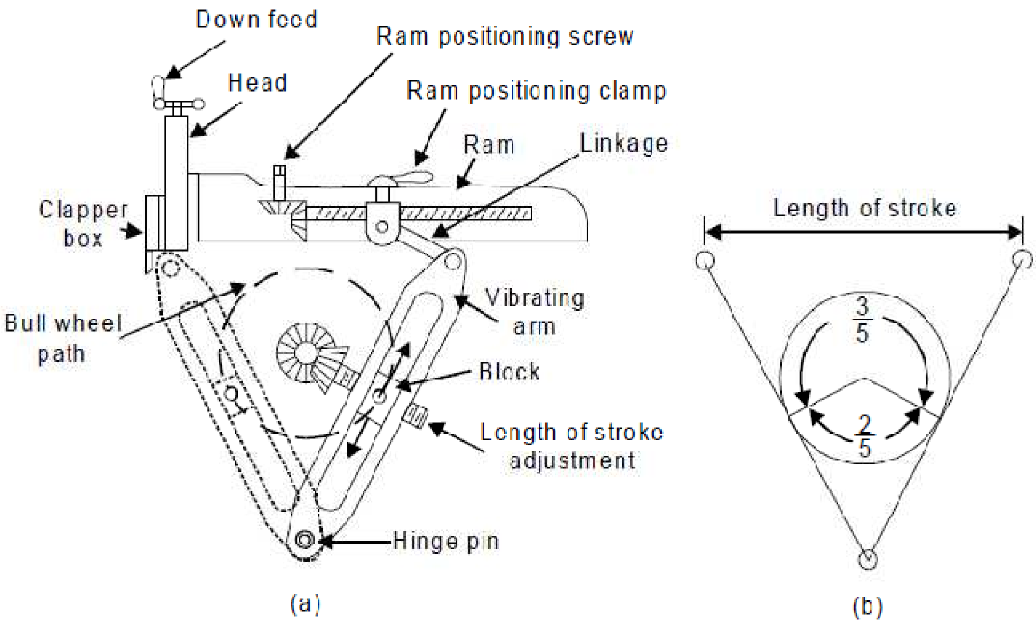


Fig.: Quick Return Mechanism

CLASSIFICATIONS OF SHAPERS:

The shapers are classified as follows:

1. ACCORDING TO THE RAM DRIVING MECHANISM:

According to the ram driving mechanism, the shapers are classified as follows:

(a) CRANK SHAPER:

In a crank shaper, a crank and a slotted lever quick return motion mechanism is used to give reciprocating motion to the ram. The crank arm is adjustable and is arranged inside the body of a bull gear (also called crank gear).

(b) GEARED SHAPER:

In a geared shaper, the ram carries a rack below it, which is driven by a spur gear. This type of shaper is not widely used.

(c) HYDRAULIC SHAPER:

In a hydraulic shaper, a hydraulic system is used to drive the ram. This type of shaper is more efficient than the crank and geared shaper.

2. ACCORDING TO POSITION AND TRAVEL OF RAM:

According to the position and travel of ram, the shapers are classified as follows:

(a) HORIZONTAL SHAPER:

In a horizontal shaper, the ram moves or reciprocates in a horizontal direction. This type of shaper is mainly used for producing flat surfaces.

(b) VERTICAL SHAPER:

In a vertical shaper, the ram reciprocates vertically in the downward as well as in upward direction. This type of shaper is very convenient for machining internal surfaces, keyways, slots or grooves.

3. ACCORDING TO THE DIRECTION OF CUTTING STROKE:

According to the direction of cutting stroke, the shapers are classified as follows:

(a) PUSH-CUT SHAPER:

In a push-cut shaper, the ram pushes the tool across the work during cutting operation. In other words, forward stroke is the cutting stroke and the backward stroke is an idle stroke. This is the most general type of shaper used in common practice.

(b) DRAW-CUT SHAPER:

In a draw-cut shaper, the ram draws or pulls the tool across the work during cutting operation. In other words, the backward stroke is the cutting stroke and forward stroke is an idle stroke.

4. ACCORDING TO THE DESIGN OF THE TABLE:

According to the design of the table, the shapers are classified as:

(a) STANDARD OR PLAIN SHAPER:

In a standard or plain shaper, the table has only two movements i.e., horizontal and vertical, to give the feed. It cannot be swiveled or tilted.

(b) UNIVERSAL SHAPER:

In a universal shaper, in addition to the above two movements, the table can be swiveled about a horizontal axis parallel to the ram and the upper portion of the table can be tilted about the other horizontal axis perpendicular to the first axis. This type of shaper is mostly used in tool room work.

SPECIFICATIONS OF A SHAPER:

The shaper is specified as follows:

1. Maximum length of stroke is millimeters,
2. Size of the table, i.e., length, width and depth of the table,
3. Maximum vertical and horizontal travel of the table,
4. Maximum number of strokes per minute,
5. Power of the drive motor,
6. Type of quick return mechanism.
7. Floor space required, and
8. Weight.

LABORATORY EXERCISE_2

SHAPER

AIM: To prepare horizontal surface/vertical surface/slots or V-grooves on a shaper.

TOOLS AND MATERIALS REQUIRED:

SEQUENCE OF OPERATIONS:

RESULT:

PRECAUTIONS:

MILLING- INTRODUCTION:

Milling is the machine operation in which the removal of metal from the work piece takes place due to a rotating cutting tool (cutter) when the work is fed past it. The cutter has multiple cutting edges and rotates at a very fast rate. The rotating cutting tool known as the "Milling Cutter" is a multiple point tool having the shape of a solid revolution with cutting teeth arranged either on the periphery or on end or on both. The revolving cutter is held on a spindle or arbor and the work piece is clamped or bolted on the machine table or may be in a vise or a three jaw chuck or an index head held or a rotary table etc. The milling process is employed for producing flat contoured or helical surfaces, for making helical grooves, to cut teeth and toothed gears.

WORKING PRINCIPLE OF MILLING:

Below figure illustrates the working principle employed in metal removing operation on a milling machine. The job or work piece is rigidly clamped on the table of the machine or in a chuck or an index head and revolving multiteeth cutter is mounted either on a spindle or an arbor. The job is fed slowly past the cutter. The work can be fed in a vertical, longitudinal or cross direction. With the movement of the work piece, the cutter teeth remove metal from the job in the form of chips to produce the desired shape.

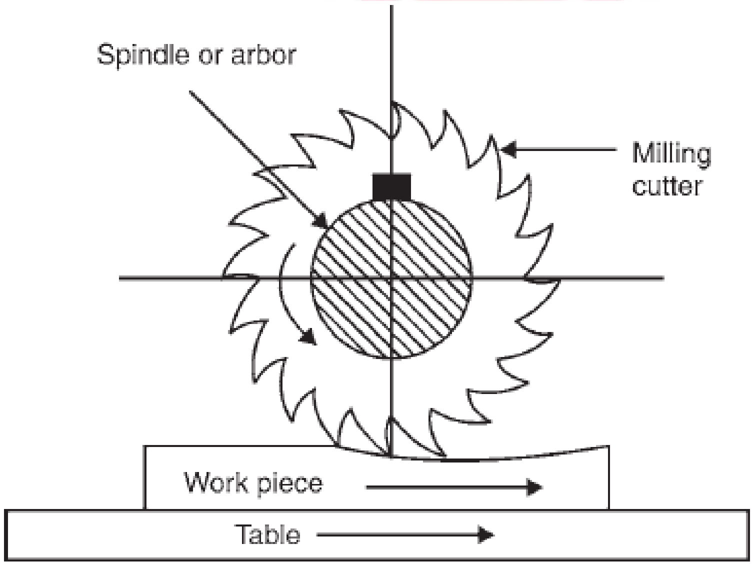


Fig.: Working Principle of Milling Machine

MILLING METHODS:

There are two distinct methods of milling classified as follows:

1. Up-milling or conventional milling- In the up-milling or conventional milling, the metal is removed in form of small chips by a cutter rotating against the direction of travel of the work piece.

2. Down milling or climb milling- Down milling is also known as climb milling. In this method, the metal is removed by a cutter rotating in the same direction of feed of the work piece.

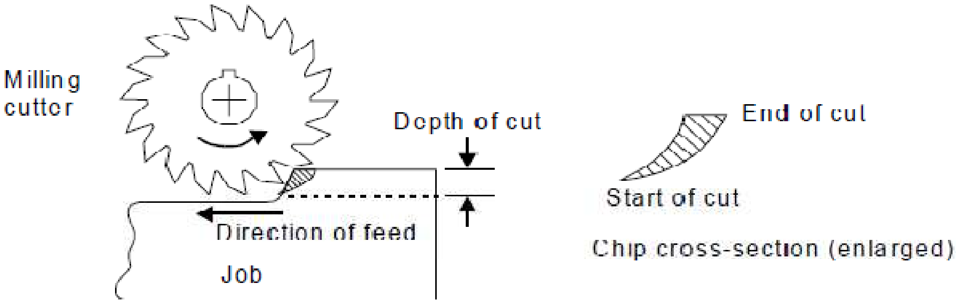


Fig. Principal of up-milling

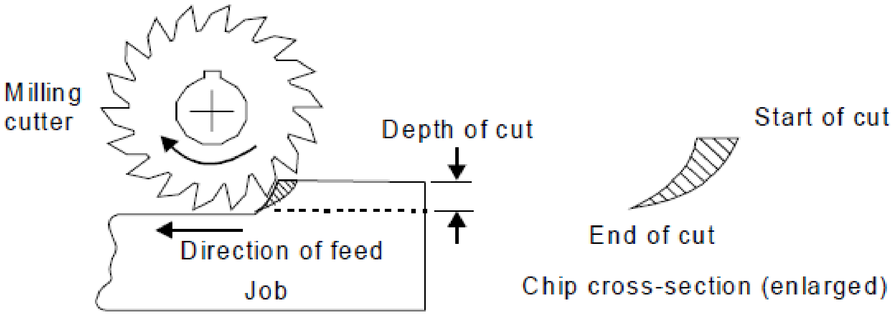


Fig. Principal of down-milling

TYPES OF MILLING MACHINES:

The milling machines are available in different shapes and sizes. These machines may be classified as follows:

(1) COLUMN AND KNEE TYPE MILLING MACHINES:

These general purpose machines have two main structural elements a vertical column, and a knee like casting. The knee which is attached to a vertical column can slide in a vertical direction on the column so that the various heights of work pieces can be accommodated in the work table. The traversal movement of the work table is provided by mounting the table on the saddle which in turn is mounted on the knee. The table which is mounted on the saddle moves at right angles to the saddle. The work piece is positioned and clamped on the table. The horizontal, vertical column and knee type milling machines are illustrated below:

(a) HORIZONTAL MILLING MACHINES:

These machines can be further classified as plain or universal milling machines. In a plain milling machine, the table cannot be swiveled in a horizontal plane. The table may be fed in a longitudinal, cross or vertical directions on a plain milling, machine. In case of universal milling machine, the table can be swiveled up to 45° in a horizontal plane to the right or left. This arrangement makes the angular and helical milling operations by using the universal milling machine. In addition to the three principal movements as incorporated in a plain milling machine, the table can be fed at an angle to the milling cutter.

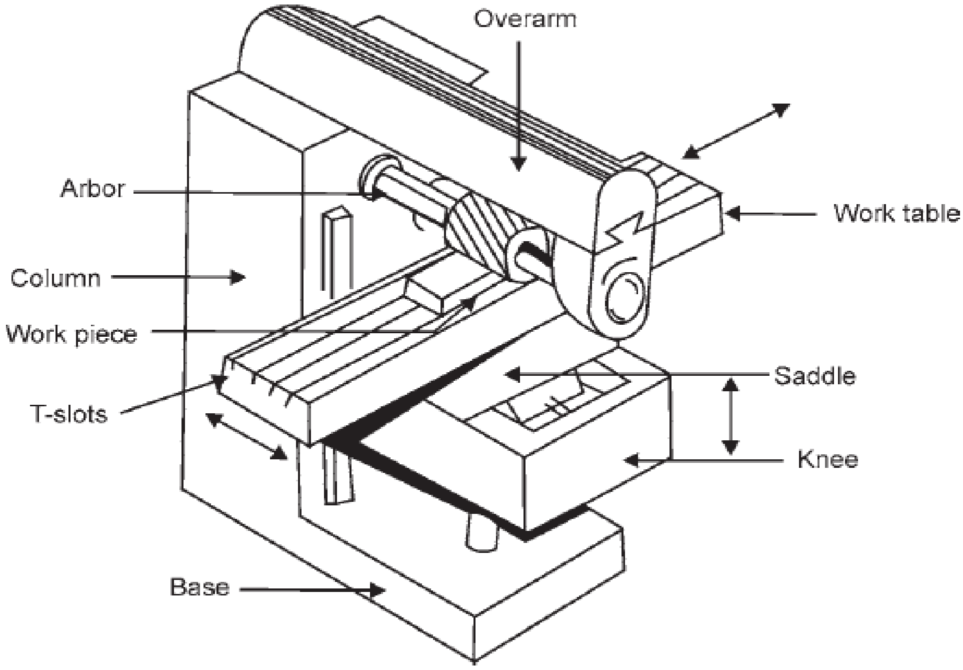


Fig.: Horizontal Spindle Column and Knee Type

(b) VERTICAL MILLING MACHINES:

In vertical knee type milling machines, the position of the cutter spindle is vertical. Though it has the same table movements as in plain milling cutter, the spindle head swivel or it may be a combination of the sliding and swivel head type. These machines are suitable for end milling and face milling operations.

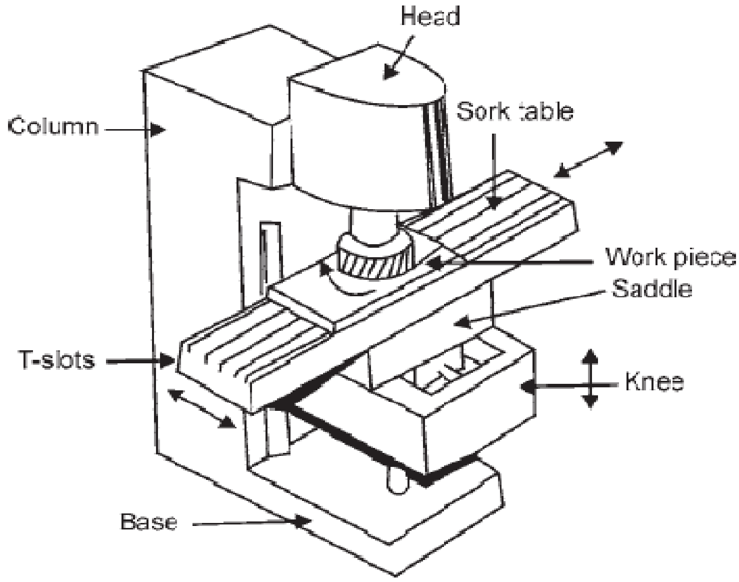


Fig.: Vertical Spindle Column and Knee Type

(c) RAM TYPE MILLING MACHINES:

In the ram type milling machines, the milling head is mounted at the front end of the ram through a single or double swivel joint which in turn is mounted on the top of the column. The ram can move forward and backward in a direction parallel to the saddle movement. These additional features enable the spindle axis to move in a horizontal, vertical and an angular direction. These ram type milling machines can be further classified as, (*i*) Turret ram type milling machine and (*ii*) Ram head milling machine.

(2) BED TYPE MILLING MACHINES:

Bed type milling machines are comparatively heavier and rigid than column and knee type milling machines. In these machines, the table is mounted over a fixed bed in the place of a knee. The spindle head imparts the cross or vertical motion instead of a table. Depending on the number of spindle heads provided in these machines, they can be 'named as simplex, duplex and triplex milling machines. Their types may be classified as horizontal or vertical, based on the orientation of the spindle axis.

(a) MANUFACTURING OR FIXED BED TYPE MILLING MACHINE:

In addition to the manual adjustment of all slides in these machines, the automatic cycle of operation for feeding the table feature is incorporated to give an advantage in repetitive type of work. This automatic feeding cycle of the table includes the start, rapid approach, cutting feed, rapid traverse to the next job, quick return and stop. These machines are particularly suitable for large production work.

(b) HORIZONTAL BED TYPE MILLING MACHINES:

These machines are usually provided with the above said features. As the name implies, the spindle is mounted horizontally and it can be adjusted up or down a column fitted to the side of the bed. The available types of horizontal bed type milling machines are the simplex and duplex milling machine.

(c) VERTICAL BED TYPE MILLING MACHINE:

The spindle is mounted vertically in these machines. All the other features in horizontal bed type milling machines are incorporated in this machine. The transverse movement can be obtained by mounting the head unit over a cross-arm.

(3) PLANER TYPE MILLING MACHINES:

As the name implies, the machines structure resembles a planer. The table which carries the work piece moves longitudinally and it is fed against a revolving cutter. This machine is distinguished from a planer machine by the variable table feeding movement and the rotating cutter features. These machines are used for heavy stock removal in large work pieces and for duplication of profiles and contours.

(4) SPECIAL PURPOSE MILLING MACHINES:

Special purpose milling machines have been developed to suit for specific kinds of work more easier than the conventional machines. Some of the common features incorporated from conventional machines are the provision for moving the work piece or tool in different directions and the spindle for rotating the cutter.

(a) ROTATING TABLE MILLING MACHINE:

These high-production machines have a circular table which rotates about a vertical axis. Their construction is a modification to a vertical milling machine. The rotary table milling machines are adapted for machining fiat surfaces by using face milling cutters. The cutters are mounted on two vertical spindles, one for roughing and the other for finishing the work. These machines can have two or more cutter spindles. The spindle head can be set at different heights along the vertical ways of the column and while the milling is in progress the operator can continuously load or unload the work pieces in the machine.

(b) DRUM TYPE MILLING MACHINE:

The drum milling machines are adopted for the machining of two end faces of a work piece simultaneously in a continuous machining cycle. The drum which rotates in a horizontal axis is used for clamping the work pieces. The face milling cutters are mounted on a number of horizontal spindles and removes metal from the two end faces of the work piece. The parts are finished in one complete turn of the central drum.

(c) TRACER CONTROLLED MILLING MACHINE:

It reproduces the complex shapes like mold cavities and core, cams, dies, etc., by tracing the shape of the master model or template. The shapes are reproduced in the work pieces by synchronized movements of the cutter and tracing element. This provides an automatic control to the feeding motion of the machine. The stylus traces the master or template to produce the coordinates of the cutter path which is used to produce the work piece shapes.

(d) THREAD MILLING MACHINES:

This machine is used for cutting threads and worms. Threads produced by this thread milling operation give better finish and greater accuracy than the conventional thread cutting methods. The milling tools having single row of teeth or a number of such rows used for these thread milling operations.

(e) KEY-WAY MILLING MACHINE:

The key-way milling machines are used for parts requiring the key-ways in a high degree of accuracy. These machines are used in large batch production. It uses an automatic cycle to machine the key-way which includes the horizontal movement of the work table, to feed of cutter, transverse movement of cutter, etc.

(f) SKIN AND SPAR MILLING MACHINES:

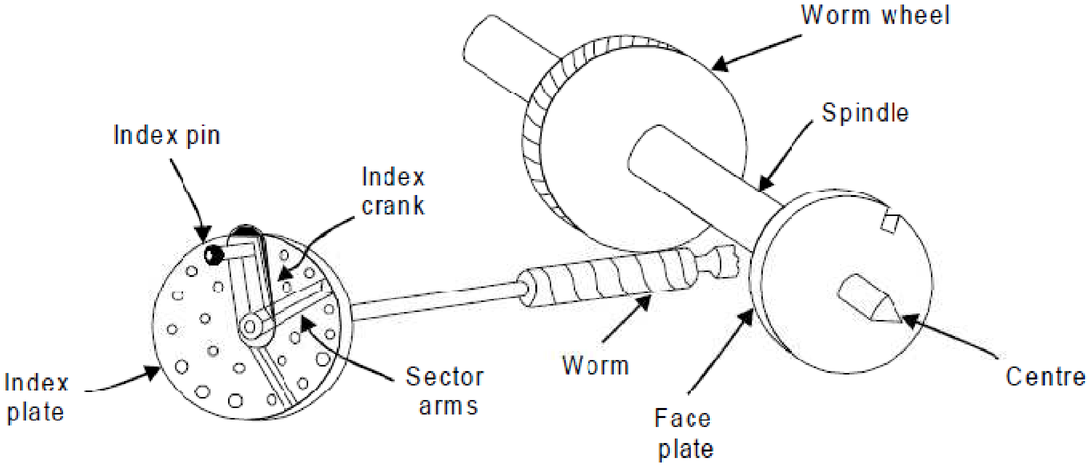
The structure of both these machines resembles a planer machine in appearance. In ‘spar milling machine’, the work remains stationary and the rotating cutters are moved to and fro to perform the operations. In addition to the above said principle, the skin milling machine’ uses another design for the machining purposes in which the work piece is mounted on a table which is moved past the revolving milling cutters. The machines may have horizontal or vertical spindle axis. These machines are mostly used in aircraft industries.

(g) PLANETARY MILLING MACHINE:

These machines are so called because of their planetary (circular) path of the cutters during the operation. The work is held stationary while all the movements which are essential for the cutting are made by the revolving cutters and are the principal features that distinguish this machine from the normal method. The spindle types of both horizontal and vertical designs are available. The planetary milling machines are used for milling both internal and external threads and surfaces.

INDEXING:

Indexing is the operation of dividing the periphery of a piece of work into any number of equal parts. In cutting spur gear equal spacing of teeth on the gear blank is performed by indexing. Indexing is accomplished by using a special attachment known as dividing head or index head as shown in Figure below-



MILLING MACHINE OPERATIONS:

The operations that can be performed on a milling machine are broadly classified as follows:

(1) Plain Milling (2) Face Milling (3) Angular Milling (4) Staggered Milling (5) Form Milling (6) End Milling

PLAIN MILLING:

It is also known by slab milling. A plain milling cutter is used to produce a plain, flat, horizontal surface parallel to the axis of rotation. The work is mounted on a table and the tool is secured properly on the spindle. The speed and feed of the machine is set up before starting the operation and the depth of cut is adjusted by rotating the vertical feed screw of' the table.

FACE MILLING:

The face milling operation is used for machining flat surfaces by a face milling cutter which is rotating in an axis perpendicular to the work surface. The depth of cut is adjusted by rotating the tables cross feed screw.

ANGULAR MILLING:

The angular milling is the operation used for machining flat surfaces at an angle. Depending upon whether the machining has to be carried out in a single or two mutually inclined surfaces, a single or double angle cutter may be used. The V-blocks of any size can be machined by this operation.

STAGGERED MILLING:

These types of cutters are narrow and cylindrical having staggered teeth and with alternate teeth having opposite helix angles. These cutters are used for milling deep slots.

FORM MILLING:

These types of milling cutters are used to cut some profile or contour on the work piece. These can be used to cut convex, concave, corner rounding and gear tooth in the work piece.

END MILLING:

These types of cutters have teeth on the circumferential surface at one end. They are used for facing, profiling and end milling operations.

All the operations of Milling Machine are shown in the following figures:-

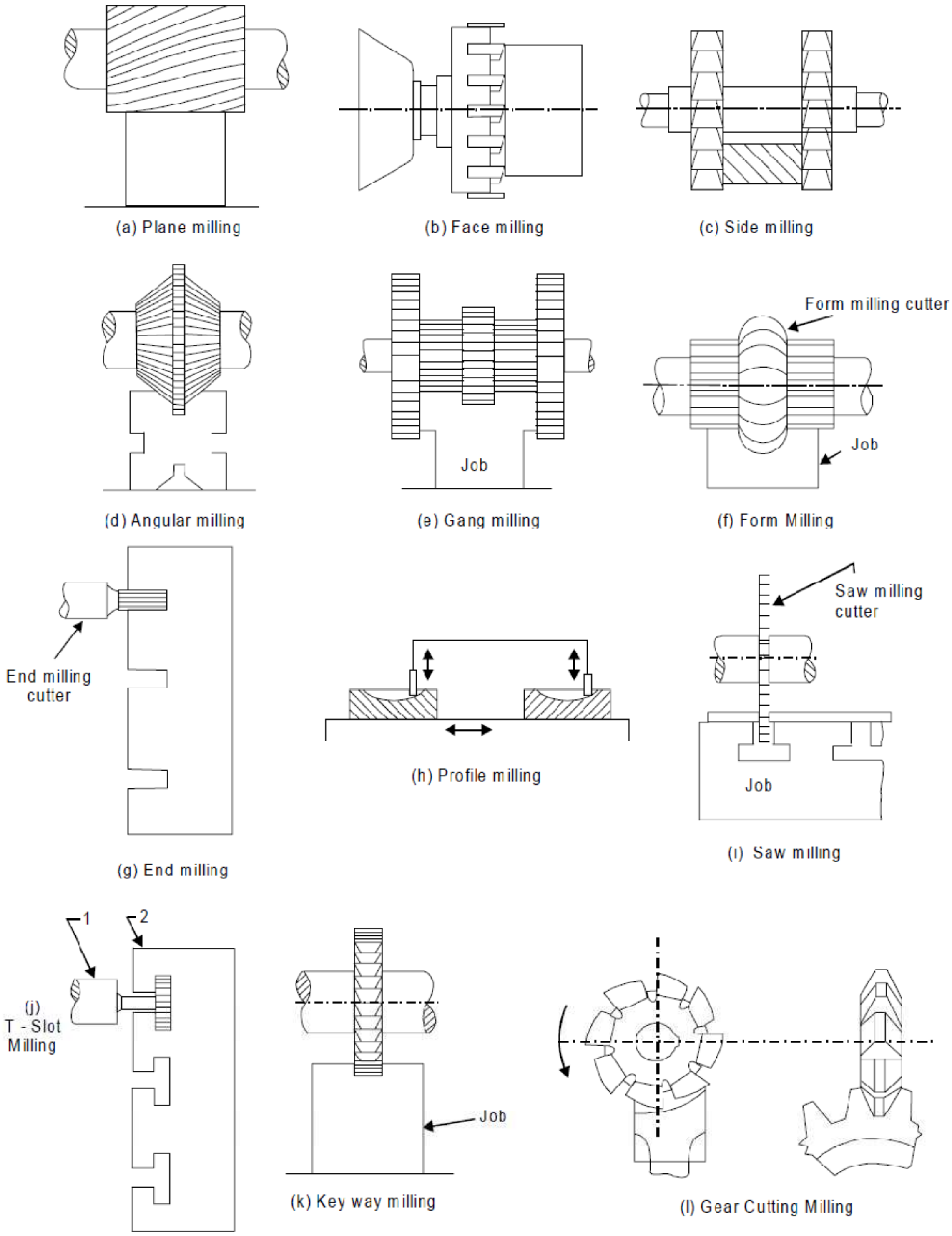


Fig. Various types of milling operations

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LABORATORY EXERCISE_3

MILLING MACHINE

AIM: To prepare a job involving side and face milling on a milling machine.

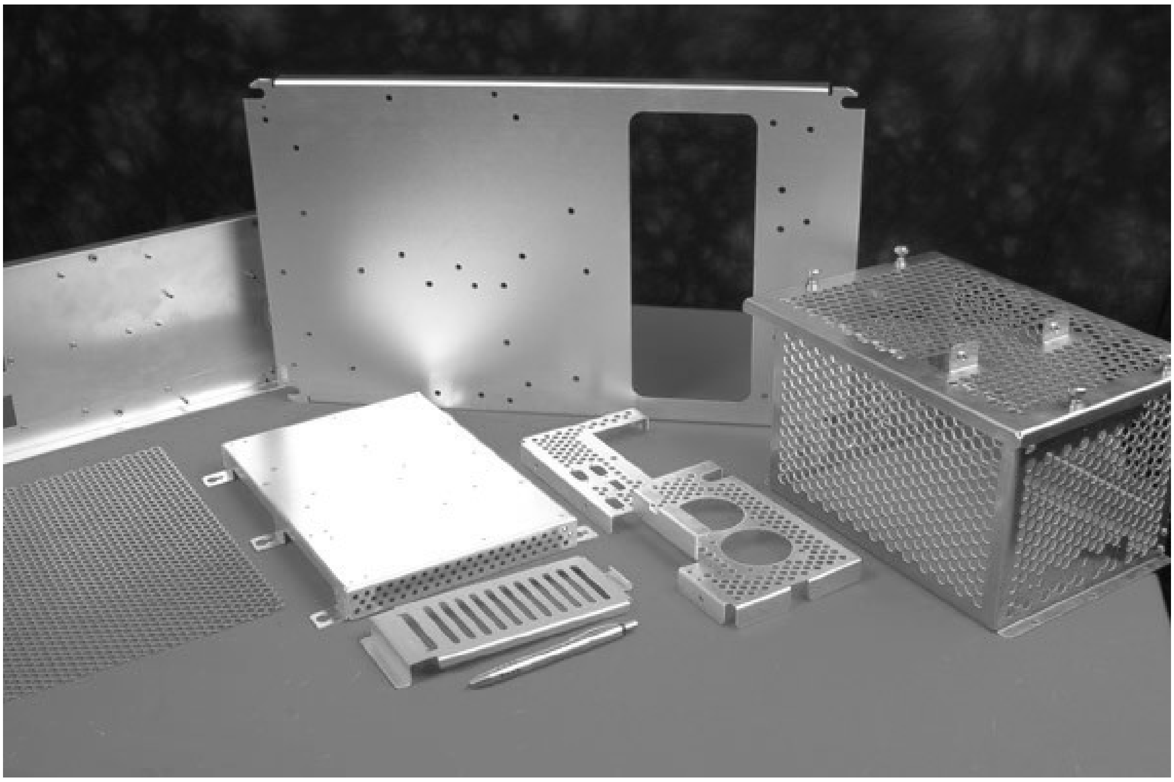
TOOLS AND MATERIALS REQUIRED:

SEQUENCE OF OPERATIONS:

RESULT:

PRECAUTIONS:

SHEET METAL FORMING



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SAFETY PRECAUTIONS OF SHEET METAL:

1. Heavy sheet must be handled by using gloves.
2. Check whether head portion of the mallet and hammer should be tightly fixed to the handle.
3. Respective snips should be selected according to the sheet metal thickness.
4. Burrs should be removed in the edges of the sheet metal after the cutting process.
5. Do not let sheet metal slip through your hands.
6. While cutting operation, blade should be perpendicular to the job and along the marking line.
7. Adequate care should be taken while folding, hamming or scamming operations.
8. Waste materials should be cleaned by using wire brush.
9. Necessary sheet metal working tools should be collectively selected and handled because that avoids confusion.
10. High force should not be applied while leveling the plate.

GENERAL PROCEDURE FOR SHEET METAL WORK:

1. The exact size and shape of the sheet to be cut is given by the development of the concerned object.
2. The development is drawn on a flat sheet metal and then the sheet is cut.
3. The cut sheet is folded or rolled to the required shape before the joints are made by welding or any other form of fastening.

SPECIFICATION OF SHEET METAL:

The sheets are specified by standard gauge numbers. Each gauge designates a definite thickness. The gauge number can be identified by standard wire gauge (or) S.W.G.
The following table shows gauge numbers and their corresponding thicknesses of sheet. The larger the gauge numbers, the lesser the thickness and vice versa.

S.W.G.	10	12	14	16	18	20	22	25	26	30
Thickness	3.2	2.6	2.0	1.6	1.2	0.9	0.7	0.6	0.4	0.3

TOOLS USED IN SHEET METAL WORK:

SNIPS (OR) SHEARS:

Snips are hand sheets, varying in length from 200mm to 600mm. 200mm and 250mm lengths are most commonly used. Curved snips or bend snips are used for trimming along inside curves.

STRIKING TOOLS:

HAMMERS:

Hammers are used in sheet metal work for following: stretching, leveling, riveting, strengthening of sheet metal joints, etc.

PUNCHES:

In sheet metal work, punch is used foe making out work, locating centers etc. there are two types of punches.

SUPPORTING TOOLS:

STAKES:

Stakes are nothing but anvils of sheet metal workers, used for bending, hamming, scamming, forming, etc. using hammers or mallet.

BENDING TOOLS:

Flat nose pliers and round nose pliers are used in sheet metal work for forming and holding work.

LAYOUT TOOLS:

SCRIBER:

It is a long wire of steel with its one end sharply pointed and hardened, to scratch a line on the sheet metal for laying out patterns.

DIVIDERS:

Dividers are used for drawing circles or arcs on sheet metal. They are used to mark a desired distance between two points and to divide lines into equal parts.

TRAMMELS:

It is used for making of arcs and circles. Maximum size of the arc that can be described depends on the length of the beam in scriber.

GROOVING TOOLS:

In order to join the sheet metal jobs, their ends are grooved with the help of grooving tools. This process is called grooving.

SHEET METAL OPERATIONS:

SHEARING:

The following are the basic shearing operations.

1. Cutting off
2. Parting
3. Blanking
4. Punching
5. Notching
6. Slitting
7. Lancing
8. Nabbing
9. Trimming

BENDING:

It means that the metal is stressed beyond the elastic limit, so that the metal is bent into right angle and forming occurs when complete items or parts are shaped. It incorporates angle bending, roll forming and scamming.

JOINING:

After bending the metal is joined by rivet, soldering or brazing. The main difference between welding on one hand and soldering and brazing on the other is that, in either soldering or in brazing process, the temperatures used are not high enough to cause melting of parent metals to be joined. In soldering temperatures up to 427°C are used and in brazing process, temperatures above 427°C are employed.

LABORATORY EXERCISE_1

SHEET METAL FORMING

AIM: To make a square tray from a given metal sheet.

TOOLS REQUIRED: Mallet, Snip, Stake, Steel Rule, Ball peen hammer, Straight edge, Rivets, Scriber, etc.

PROCEDURES:

1. The given metal sheet is smoothed using mallet.

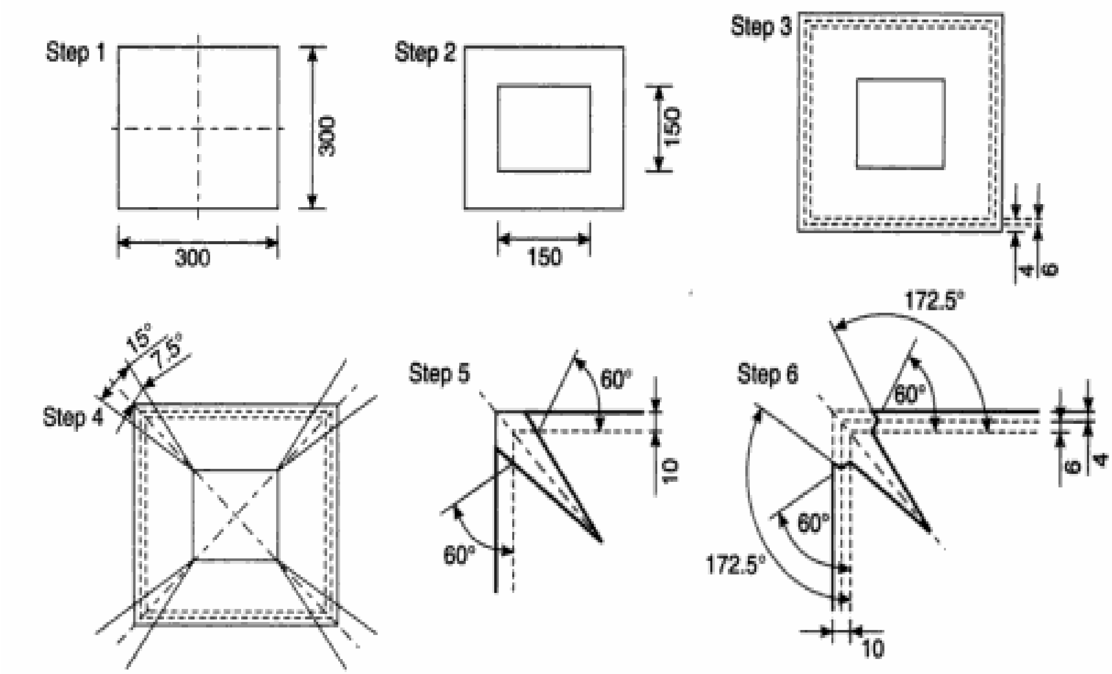
2. The development of square tray is drawn on the sheet with given dimensions using the scriber.

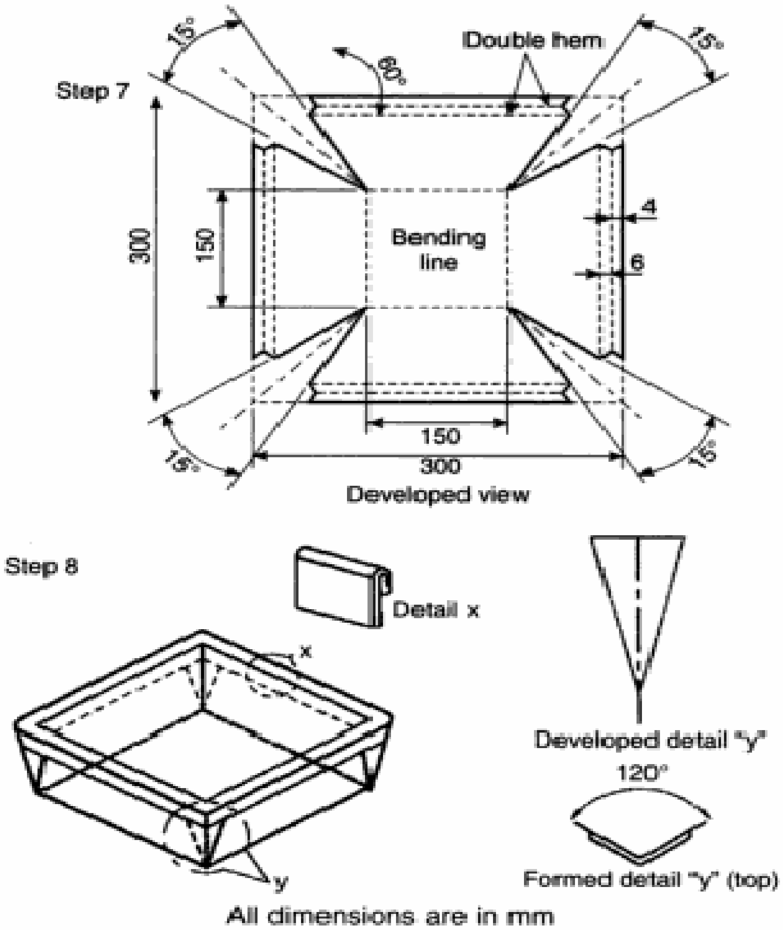
3. The unmarked and excess portions in the sheet are removed using snip.

4. Folding is done as per the given order using mallet and stake.

5. Bending is done as per the given dimension using the stake and mallet.

6. The tray is riveting using the given rivets and hammer.





RESULT:

PRECAUTIONS:

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WELDING

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WELDING:

Welding is the process of joining metals by melting the parts and then using a filler to form a joint. Welding can be done using different energy sources, from a gas flame or electric arc or a laser or ultrasound.

Now, it is extensively used in manufacturing industry, construction industry (construction of ships, tanks, locomotives and automobiles) and maintenance work, replacing riveting and bolting, to a greater extent.

TYPES OF WELDING:

- **Plastic Welding or Pressure Welding:**

The piece of metal to be joined are heated to a plastic state and forced together by external pressure. Example: Resistance welding.

- **Fusion Welding or Non-Pressure Welding**

The material at the joint is heated to a molten state and allowed to solidify. Example: Gas welding, Arc welding.

CLASSIFICATION OF WELDING PROCESSES:

(i) Arc welding
- Carbon arc
- Metal arc
- Metal inert gas
- Tungsten inert gas
- Plasma arc
- Submerged arc
- Electro-slag

(ii) Gas Welding
- Oxy-acetylene
- Air-acetylene
- Oxy-hydrogen

(iii) Resistance Welding
- Butt
- Spot
- Seam
- Brazing
- Soldering
- Projection
- Percussion

(iv) Thermit Welding

(v) Solid State Welding
- Friction
- Ultrasonic
- Diffusion
- Explosive

(vi) Newer Welding
- Electron-beam
- Laser

(vii) Related Process
- Oxy-acetylene cutting
- Arc cutting
- Hard-facing

OXY-FUEL WELDING/ GAS WELDING:

Oxy-fuel welding (commonly called oxyacetylene welding, oxy welding, or **gas welding**) is a process that uses fuel gases and oxygen to weld metals. In Oxy-fuel welding, a welding torch is used to weld metals. Welding metal results when two pieces are heated to a temperature that produces a shared pool of molten metal. The molten pool is generally supplied with additional metal called filler. Filler material depends upon the metals to be welded.

Torches that do not mix fuel with oxygen (combining, instead, atmospheric air) are not considered oxyfuel torches and can typically be identified by a single tank (Oxy-fuel welding generally requires two tanks, fuel and oxygen). Most metals cannot be melted with a single-tank torch. As such, single tank torches are typically used only for soldering and brazing, rather than welding.

APPARATUS:

The apparatus used in gas welding consists basically of an oxygen source (125 kg/cm^2) and a fuel gas source (Acetyelene-16 kg/cm^2), two pressure regulators (Oxygen- 1 kg/cm^2 and Acetylene- 0.15 kg/cm^2) and two flexible hoses (one of each for each cylinder), and a torch.

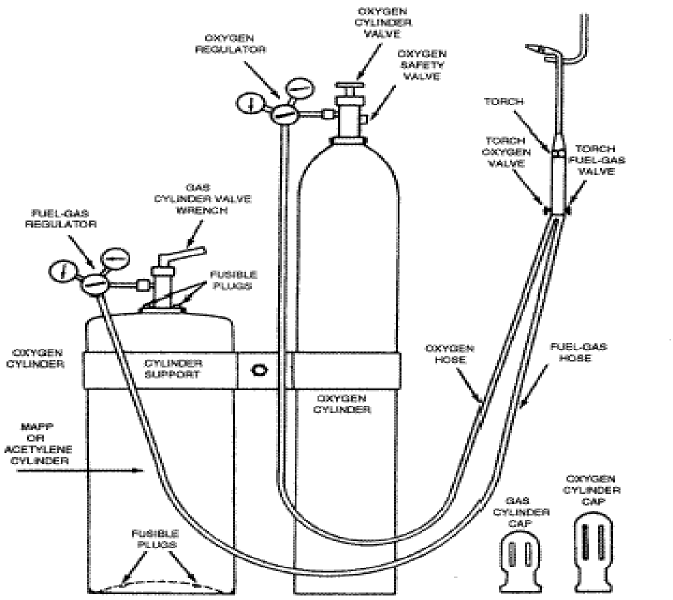


Fig.: Schematic diagram of Gas Welding

PRESSURE REGULATOR:

The regulator is used to control pressure from the tanks by reducing pressure and regulating flow rate. Oxy-gas regulators usually have two stages: The first stage of the regulator releases the gas at a constant rate from the cylinder despite the pressure in the cylinder becoming less as the gas in the cylinder is used. The second stage of the regulator controls the pressure reduction from the intermediate pressure to low pressure. It is constant flow. The valve assembly has two pressure gauges, one indicating cylinder pressure, and the other indicating

hose pressure. Some oxy-gas regulators only have one stage, and one pressure gauge. With those the gas flow gets less as the cylinder pressure drops.

GAS HOSES:

The hoses used are specifically designed for welding. The hose is usually a double-hose design, meaning that there are two hoses joined together. The oxygen hose is green and the fuel hose is red. The type of gas the hose will be carrying is important because the connections will have different threads for different types of gas. Fuel gases (red) will use left-hand threads and a groove cut into the nut, while the oxygen (green) will use right-hand threads. This is a safety precaution to prevent hoses from being hooked up the wrong way. There are basically two types of connections that can be used. The first is using a jubilee clip. The second option is using a crimped connector. The second option is probably safer as it is harder for this type of connection to come loose. The hoses should also be clipped together at intervals approximately 3 feet apart.

NON-RETURN VALVE:

Between the regulator and hose, and ideally between hose and torch on both oxygen and fuel lines, a flashback arrestor and/or non-return valve should be installed to prevent flame or oxygen-fuel mixture being pushed back into either cylinder and damaging the equipment or making a cylinder explode.

The flashback arrestor (not to be confused with a check valve) prevents shock waves from downstream coming back up the hoses and entering the cylinder (possibly rupturing it), as there are quantities of fuel/ oxygen mixtures inside parts of the equipment (specifically within the mixer and blowpipe/nozzle) that may explode if the equipment is incorrectly shut down; and acetylene decomposes at excessive pressures or temperatures. The flashback arrestor will remain switched off until someone resets it, in case the pressure wave created a leak downstream of the arrestor.

CHECK VALVE:

A check valve lets gas flow in one direction only. Not to be confused with a flashback arrestor, a check valve is not designed to block a shock wave. The pressure wave could occur while the ball is so far from the inlet that the pressure wave gets past before the ball reaches its off position. A check valve is usually a chamber containing a ball that is pressed against one end by a spring: gas flow one way pushes the ball out of the way, and no flow or flow the other way lets the spring push the ball into the inlet, blocking it.

TORCHES:

The torch is the part that the welder holds and manipulates to make the weld. It has a connection and valve for the fuel gas and a connection and valve for the oxygen, a handle for the welder to grasp, a mixing chamber (set at an angle) where the fuel gas and oxygen mix, with a tip where the flame forms. The top torch is a welding torch and the bottom is a cutting torch.

WELDING TORCH:

A welding torch head is used to weld metals. It can be identified by having only one or two pipes running to the nozzle and no oxygen-blast trigger.

1) **ROSE-BUD TORCH:** A rose-bud torch is used to heat metals for bending, straightening, etc. where a large area needs to be heated. It is called as such because the flame at the end looks like a rose-bud. A welding torch can also be used to heat small area such as rusted nuts and bolts. In this case, no filler rod is used with the torch.

2) **INJECTOR TORCH:** A typical Oxy-fuel torch, called an equal-pressure torch, merely mixes the two gasses. In an injector torch, high pressure oxygen comes out of a small nozzle inside the torch head so that it drags the fuel gas along with it, via venturi effect.

FUELS:

Fuel processes may use a variety of fuel gases, the most common being acetylene. Other gases that may be used are propylene, liquefied petroleum gas (LPG), propane, natural gas, hydrogen, and MAPP gas.

ACETYLENE: Acetylene is the primary fuel for oxy-fuel welding and is the fuel of choice for repair work and general welding. Acetylene gas is shipped in special cylinders designed to keep the gas dissolved.

The cylinders are packed with porous materials (e.g. kapok fiber, diatomaceous earth, or (formerly) asbestos), then filled to around 50% capacity with acetone, as acetylene is acetone soluble. This method is necessary because above 207 kPa (30 lbf/in^2) (absolute pressure) acetylene is unstable and may explode. There is about 1700 kPa (250 lbf/in^2) pressure in the tank when full. Acetylene when combined with oxygen burns at a temperature of 3200 °C to 3500 °C (5800 °F to 6300 °F), highest among commonly used gaseous fuels. As fuel acetylene's primary disadvantage, in comparison to other fuels, is high cost. As acetylene is unstable at a pressure roughly equivalent to 33 feet/10 meters underwater, water submerged welding is reserved for hydrogen rather than acetylene.

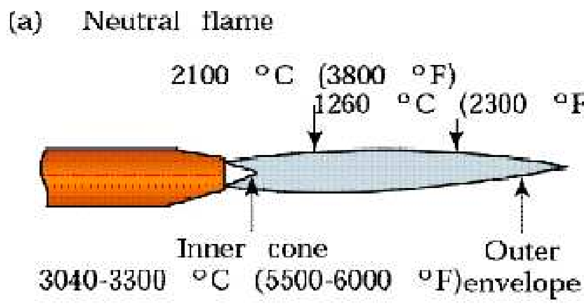
THE ROLE OF OXYGEN:

Oxygen is not the fuel: It is what chemically combines with the fuel to produce the heat for welding. This is called 'oxidation', but the more general and more commonly used term is 'combustion'. The heat is released because the molecules of the products of combustion have a lower energy state than the molecules of the fuel and oxygen. The word "oxygen" is often shorted to 'oxy', as in the term 'oxy-acetylene torch'. Oxygen is usually produced elsewhere by distillation of liquefied air and shipped to the welding site in high pressure vessels (commonly called "tanks" or "cylinders") at a pressure of about 21000 kPa (3000 lbf/in^2 = 200 atmospheres). It is also shipped as a liquid in Dewar type vessels (like a large Thermos jar) to places that use large amounts of oxygen. It is also possible to separate oxygen from air by

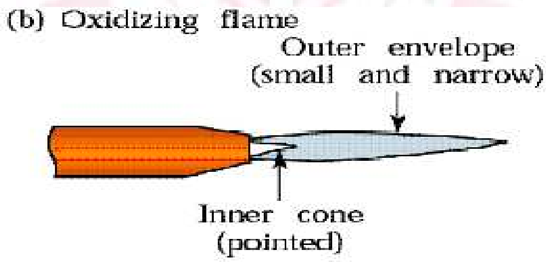
passing the air, while under pressure, through a zeolite sieve which selectively absorbs the nitrogen and lets the oxygen (and argon) pass. This gives a purity of oxygen of about 93%. This works well for brazing.

TYPES OF FLAME:

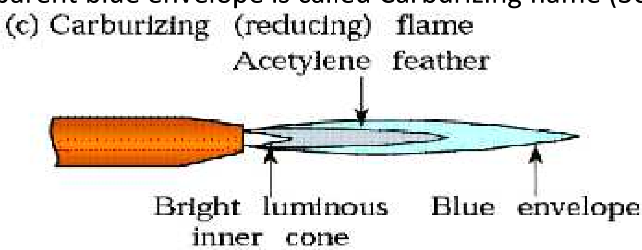
- ✓ Addition of little more oxygen give a bright whitish cone surrounded by the transparent blue envelope is called Neutral flame (It has a balance of fuel gas and oxygen) (32000c)
- ✓ Used for welding steels, aluminium, copper and cast iron



- ✓ If more oxygen is added, the cone becomes darker and more pointed, while the envelope becomes shorter and more fierce is called Oxidizing flame
- ✓ Has the highest temperature about 34000c
- ✓ Used for welding brass and brazing operation



- ✓ Oxygen is turned on, flame immediately changes into a long white inner area (Feather) surrounded by a transparent blue envelope is called Carburizing flame (30000c)



SAFETY MEASURES:

- Proper protection should be worn at all times, including protecting the eyes against glare and flying sparks.
- More than 1/7 the capacity of the cylinder should not be used per hour. This causes the acetylene to rapidly come out of solution, like carbon dioxide bubbles violently fizzing from a fizzy soft drink that has just been shaken.
- Acetylene is dangerous above 15 psi pressure. It is unstable and explosively decomposes.
- Proper ventilation when welding will help to avoid large chemical exposure.

SAFETY WITH CYLINDERS:

When using fuel and oxygen tanks they should be fastened securely upright to a wall or a post or a portable cart. An oxygen tank is especially dangerous for the reason that the oxygen is at a pressure of 21 MPa (3000 lbf/in^2 = 200 atmospheres) when full, and if the tank falls over and its valve strikes something and is knocked off, the tank will effectively become an extremely deadly flying missile propelled by the compressed oxygen, capable of even breaking through a brick wall. For this reason, never move an oxygen tank around without its valve cap screwed in place. On oxyacetylene torch system there will be three types of valves, the tank valve, the regulator valve, and the torch valve. There will be one of them for each gas. The gas in the tanks or cylinders is at high pressure. Oxygen cylinders are generally filled to approximately 2200 psi. The regulator converts the high pressure gas to a low pressure stream suitable for welding. Never attempt to directly use high pressure gas.

ARC WELDING:

EQUIPMENTS:

- A welding generator (D.C.) or Transformer (A.C.)
- Two cables- one for work and one for electrode
- Electrode holder
- Electrode
- Protective shield
- Gloves
- Wire brush
- Chipping hammer
- Goggle

ARC WELDING POWER SOURCES:

The main requirement of a power source is to deliver controllable current at a voltage according to the demands of the welding process being used. Each welding process has distinct differences from one another, both in the form of process controls required to accomplish a given operating condition and the consequent demands on the power source. Therefore, arc welding power sources are playing very important role in welding. The conventional welding power sources are:

POWER SOURCE SUPPLY:

Power Source	**Supply**
Welding Transformer	**AC**
Welding Rectifier	**DC**
Welding Generators	**AC or DC** (depending on generator)

Welding transformers, rectifiers and DC generators are being used in shop while engine coupled AC generators as well as sometimes DC generators are used at site where line supply is not available. Normally rectifiers and transformers are preferred because of low noise, higher efficiency and lower maintenance as compared to generators. Selection of power source is mainly dependent on welding process and consumable. The open circuit voltage normally ranges between 70-90V in case of welding transformers while in the case of rectifiers it is 50-80 V. However, welding voltages are lower as compared to open circuit voltage of the power source.

Based on the static characteristics power sources can be classified in two categories
- Constant current or drooping or falling characteristic power source.
- Constant potential or constant voltage or flat characteristic power source.

Constant voltage power source does not have true constant voltage output. It has a slightly downward or negative slope because of sufficient internal electrical resistance and inductance in the welding circuit to cause a minor droop in the output volt ampere characteristics.

With constant voltage power supply the arc voltage is established by setting the output voltage on the source. The power source shall supply necessary current to melt the electrode at the rate required to maintain the preset voltage or relative arc length. The speed of electrode drive is used to control the average welding current. The use of such power source in conjunction with a constant electrode wire feed results in a self regulating or self adjusting arc length system. Due to some internal or external fluctuation if the change in welding current occurs, it will automatically increase or decrease the electrode melting rate to regain the desired arc length.

DUTY CYCLE:

Duty cycle is the ratio of arcing time to the weld cycle time multiplied by 100. Welding cycle time is either 5 minutes as per European standards or 10 minutes as per American standard and accordingly power sources are designed. It arcing time is continuously 5 minutes then as per European standard it is 100% duty cycle and 50% as per American standard. At 100% duty cycle minimum current is to be drawn i.e. with the reduction of duty cycle current drawn can be of higher level. The welding current which can be drawn at a duty cycle can be evaluated from the following equation:

$$D_R \times I_R^2 = I^2 \times D_{100}$$

Where I - is current at 100% duty cycle

D_{100} - 100% duty cycle

I_R - Current at required duty cycle

D_R - Required duty cycle

MANUAL METAL ARC WELDING:

Manual metal arc welding (MMAW) or shielded metal arc welding (SMAW) is the oldest and most widely used process being used for fabrication. The arc is struck between a flux covered stick electrode and the work piece. The work pieces are made part of an electric circuit, known as welding circuit. It includes welding power source, welding cables, electrode holder, earth clamp and the consumable coated electrode. Figure below shows details of welding circuit.

GAS METAL ARC WELDING (GMAW) OR METAL INERT GAS WELDING (MIG):

Metal inert gas welding (MIG) or more appropriately called as gas metal arc welding (GMAW) utilizes a consumable electrode and hence, the term metal appears in the title. There are other gas shielded arc welding processes utilizing the consumable electrodes, such as flux cored arc welding (FCAW) all of which can be termed under MIG. The typical setup for GMAW or MIG welding process is shown in the Figure. The consumable electrode is in the form of a wire reel which is fed at a constant rate, through the feed rollers. The welding torch is connected to the

gas supply cylinder which provides the necessary inert gas. The electrode and the work-piece are connected to the welding power supply.

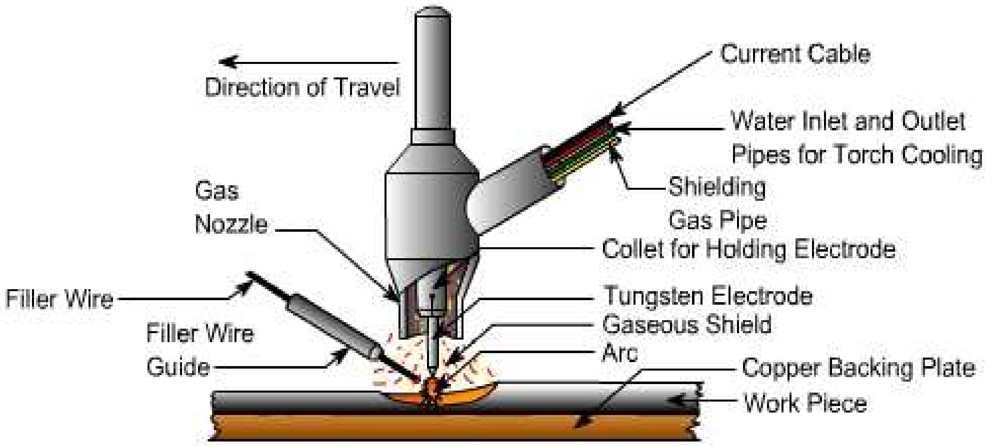


Fig.: Schematic diagram of shielded metal arc welding (SMAW)

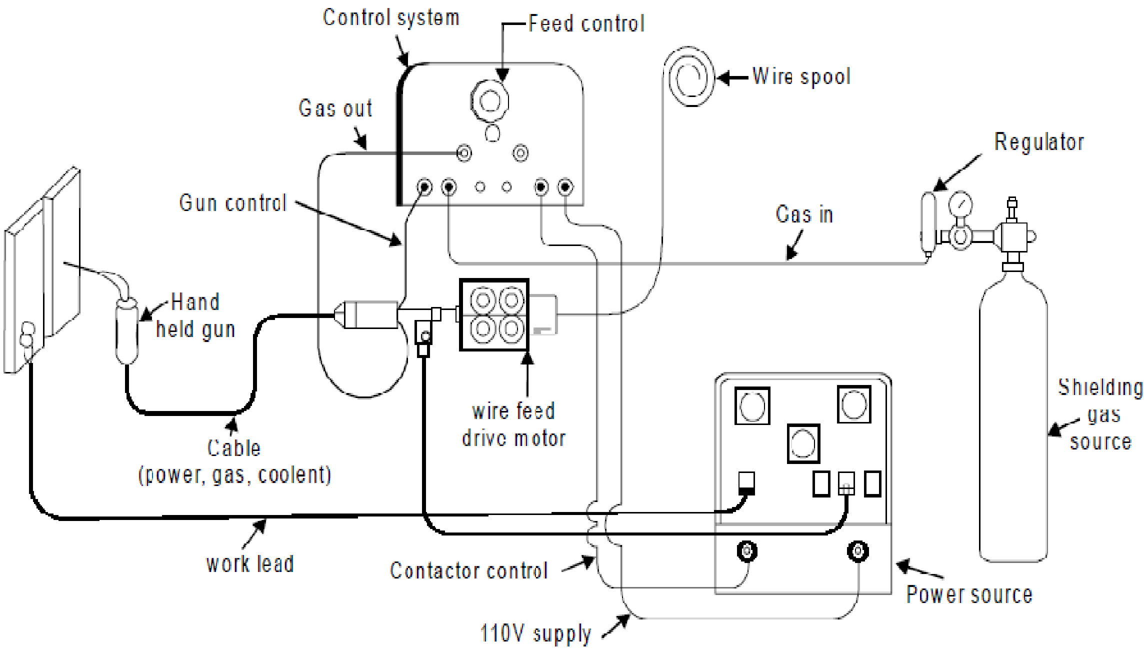


Fig.: Schematic diagram of Metal inert gas welding (MIG)

TIG WELDING:

Tungsten Inert Gas (TIG) or Gas Tungsten Arc (GTA) welding is the arc welding process in which arc is generated between non consumable tungsten electrode and work piece. The tungsten electrode and the weld pool are shielded by an inert gas normally argon and helium. Figures show the principle of tungsten inert gas welding process.

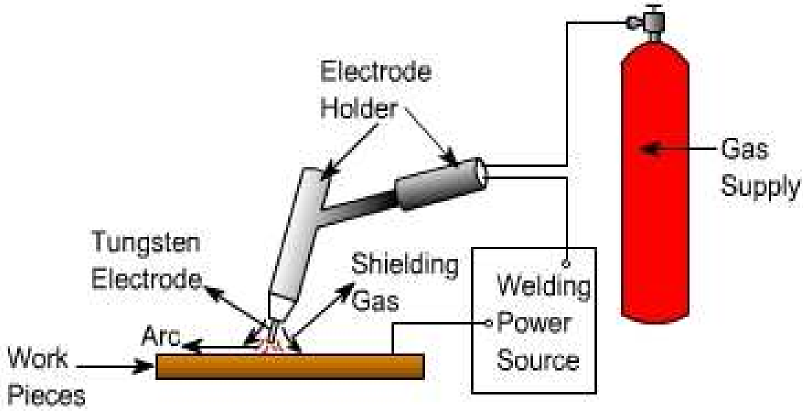


Fig.: Schematic diagram of Tungsten Inert Gas (TIG)

TIG welding can be used in all positions. It is normally used for root passes during welding of thick pipes but is widely being used for welding of thin walled pipes and tubes. This process can be easily mechanized i.e. movement of torch and feeding of filler wire, so it can be used for precision welding in nuclear, aircraft, chemical, petroleum, automobile and space craft industries. Aircraft frames and its skin, rocket body and engine casing are few examples where TIG welding is very popular.

RESISTANCE WELDING:

Resistance welding processes are pressure welding processes in which heavy current is passed for short time through the area of interface of metals to be joined. These processes differ from other welding processes in the respect that no fluxes are used, and filler metal rarely used. All resistance welding operations are automatic and, therefore, all process variables are preset and maintained constant. Heat is generated in localized area which is enough to heat the metal to sufficient temperature, so that the parts can be joined with the application of pressure. Pressure is applied through the electrodes.

The heat generated during resistance welding is given by following expression:

$$\mathbf{H = I^2 R T}$$

Where, **H** is heat generated, **I** is current in amperes, **R** is resistance of area being welded, **T** is time for the flow of current.

The process employs currents of the order of few KA, voltages range from 2 to 12 volts and times vary from few ms to few seconds. Force is normally applied before, during and after the flow of current to avoid arcing between the surfaces and to forge the weld metal during post heating. The necessary pressure shall vary from 30 to 60 N mm depending upon material to be welded and other welding conditions. For good quality welds these parameters may be properly selected which shall depend mainly on material of components, their thicknesses, type and size of electrodes.

TECHNIQUES OF WELDING:

PREPARATION OF WORK:

Before welding, the work pieces must be thoroughly cleaned of rust, scale and other foreign material. The piece for metal generally welded without beveling the edges, however, thick work piece should be beveled or veed out to ensure adequate penetration and fusion of all parts of the weld. But, in either case, the parts to be welded must be separated slightly to allow better penetration of the weld.

Before commencing the welding process, the following must be considered

a) Ensure that the welding cables are connected to proper power source.
b) Set the electrode, as per the thickness of the plate to be welded.
c) Set the welding current, as per the size of the electrode to be used.

Table. Electrode current Vs electrode size Vs plate thickness.

Plate thickness, mm	Electrode size, mm	Electrode current range, amp
1.6	1.6	40 60
2.5	2.5	50 80
4.0	3.2	90 130
6.0	4.0	120 170
8.0	5.0	180 270
25.0	6.0	300 400

NOTE: While making butt welds in thin metal, it is a better practice to tack-weld the pieces intervals to hold them properly while welding.

STRIKING AN ARC:

The following are the stages and methods of striking an arc and running a bead

a) Select an electrode of suitable kind and size for the work and set the welding current at a proper value.
b) Fasten the ground clamp to either the work or welding table.
c) Start or strike the arc by either of the following methods-

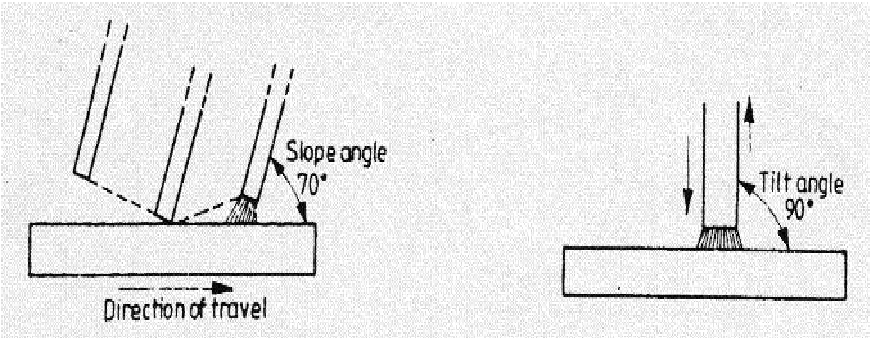
i) STRIKE AND WITHDRAW:

In this method the arc is started by moving the end of the electrode onto the work with a slow sweeping motion, similar to striking a match.

ii) TOUCH AND WITH DRAW:

In this method, the arc is started by keeping the electrode perpendicular to the work and touching or bouncing it lightly on the work. This method is preferred as it facilitates restarting the momentarily broken arc quickly. If the electrode sticks to the work, quickly bend it back and forth, pulling at the same time. Make sure to keep the shield in front of the face, when the electrode is freed from sticking.

d) As soon as the arc is struck, move the electrode along, slowly from left to right, keeping at 15º to 25º from vertical and in the direction of welding.



Strike and withdraw Touch and withdraw

Figure: striking an arc

WEAVING:

A steady, uniform motion of the electrode produces a satisfactory bead. However, a slight weaving or oscillating motion is preferred, as this keeps the metal molten a little longer and allows the gas to escape, bringing the slag to the surface. Weaving also produces a wider bead with better penetration.

TYPES OF JOINTS:

Welds are made at the junction of the various pieces that make up the weldment. The junctions of parts, or joints, are defined as the location where two or more numbers are to be joined. Parts being joined to produce the weldment may be in the form of rolled plate, sheet, pipes, castings, forgings, or billets. The five basic types of joints are listed below.

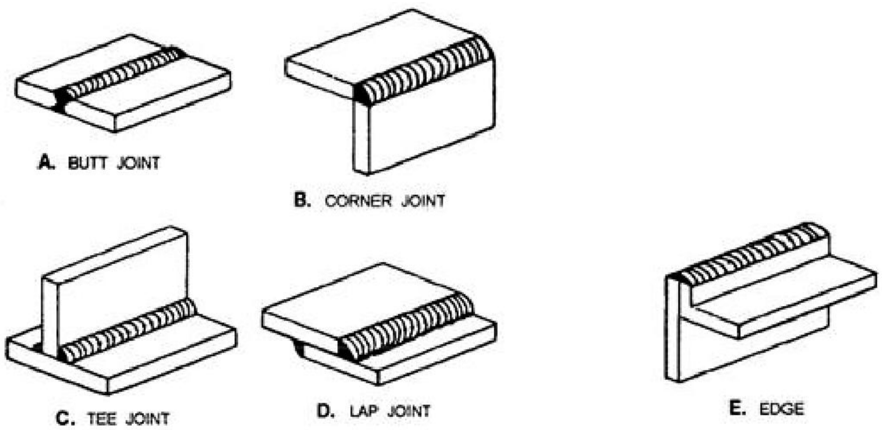


Figure: Types of welding joints.

A butt joint is used to join two members aligned in the same plane (fig. view A). This joint is frequently used in plate, sheet metal, and pipe work. A joint of this type may be either square or grooved.

Corner and tee joints are used to join two members located at right angles to each other (fig. views B and C). In cross section, the corner joint forms an L shape, and the tee joint has the shape of the letter T. Various joint designs of both types have uses in many types of metal structures.

A lap joint, as the name implies, is made by lapping one piece of metal over another (fig. view D). This is one of the strongest types of joints available; however, for maximum joint efficiency, you should overlap the metals a minimum of three times the thickness of the thinnest member you are joining. Lap joints are commonly used with torch brazing and spot welding applications.

An edge joint is used to join the edges of two or more members lying in the same plane. In most cases, one of the members is flanged, as shown in the above figure, view E. While this type of joint has some applications in plate work, it is more frequently used in sheet metal work. An edge joint should only be used for joining metals 1/4 inch or less in thickness that are not subjected to heavy loads.

WELDING POSITIONS:

Depending upon the location of the welding joints, appropriate position of the electrode and hand movement is selected. The figure shows different welding positions.

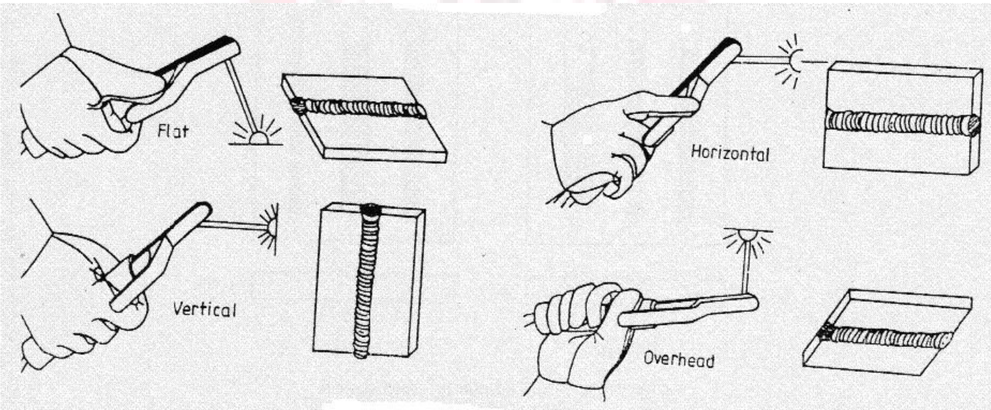


Figure: Welding positions

FLAT POSITION WELDING:

In this position, the welding is performed from the upper side of the joint, and the face of the weld is approximately horizontal. Flat welding is the preferred term; however, the same position is sometimes called down hand.

HORIZONTAL POSITION WELDING:

In this position, welding is performed on the upper side of an approximately horizontal surface and against an approximately vertical surface.

VERTICAL POSITION WELDING
In this position, the axis of the weld is approximately vertical.

OVERHEAD POSITION WELDING
In this welding position, the welding is performed from the underside of a joint.

ADVANTAGES & DISADVANTAGES OF ARC WELDING:

ADVANTAGES:
1. Welding process is simple.
2. Equipment is portable and the cost is fairly low.
3. All the engineering metals can be welded because of the availability of a wide variety of electrodes.

DISADVANTAGES:
1. Mechanized welding is not possible because of limited length of the electrode.
2. Number of electrodes may have to be used while welding long joints.
3. A defect (slag inclusion or insufficient penetration) may occur at the place where welding is restarted with a fresh electrode.

LABORATORY EXERCISE_1

ARC WELDING

AIM: To prepare a butt joint with mild steel strip using Arc welding technique.

EQUIPMENT & MATERIALS REQUIRED:

SEQUENCE OF OPERATIONS:

RESULT:

PRECAUTIONS:

LABORATORY EXERCISE_2

GAS WELDING

AIM: To prepare a butt joint with mild steel strip using Gas welding technique.

EQUIPMENT & MATERIALS REQUIRED:

SEQUENCE OF OPERATIONS:

RESULT:

PRECAUTIONS: